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COLLECTION AND DISPOSAL ALTERNATIVES FOR AGROCHEMICAL CONTAINERS IN ALBERTA

Prepared By:

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Edmonton, Alberta

March 1988

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March 21, 1988

Government of Alberta
Department of Environment
132 Legistlative Building
Edmonton, AB
T5K 2B6

Attn: The Honorable K. Kowalski
Minister of Environment

Dear Sir:

Subject: Consulting Services Agreement No. 880383

Pursuant to the terms of the subject agreement this is to advise that we have completed our report "The Potential for Recycling Agri-Chemical (Pestside/Herbicide) Containers".

A copy of our report is attached hereto for your review, additional copies required under the terms of the agreement are being forwarded to Mr. Tom Rogers.

When you have had an opportunity to study the contents, we would be most pleased to discuss any questions that you may have.

Yours truly,
APR APPLIED POLYMER RESEARCH CANADA LTD.

C. Ronden, P. Eng.
President

CPR/vs
Encl:
cc: Tom Rogers

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COMPENDIUM

The Government of the Province of Alberta, Department of Environment commisioned this study under agreement number 880383 to investigate the Technical and Economic considerations for recycling containers used to package Agrochemicals in Alberta. In the context of this study, Pesticides (including Herbicides and Insecticides) and other Agrochemical products are referred to collectively as "Agrochemicals". This investigative study has resulted in the development of proprietary processing technology wherein APR Applied Polymer Research Canada Ltd. has been able to prepare preliminary patent applications.

Contributors to this study were:

- C.P. Ronden, P.Eng. - Study Chairman
- C. Surrendi - Environmental Consultant
- T. DesLaurier - Polymer Technologist
- R. Chong - Process Engineer
- E. Kirkwood - Manufacturing Evaluation

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SECTION 1

PURPOSE & SCOPE OF STUDY

The purpose of this study is to address the technical and economic aspects of concern for the recycling and reuse of containers used to package Agrochemical products.

To successfully implement any recycling program, 5 key criteria must be met:

- A continuous source of material.
- A proven, reliable collection infrastructure.
- Adequate reclamation technology.
- Identification and creation of new end product markets for recycled materials.
- Economic viability.

The scope of this study focuses on:

- Identifying the technical problems and outlining possible solutions for material decontamination.
- Identifying potential markets for the polymeric materials recovered.
- Formulation of a viable collection infrastructure.
- Preparation of preliminary assessment on the economic viability for recycling waste Agrochemical containers.

The following photographs illustrate the build-up at an Agrochemical Container Collection Site in Canada. This site is one of the cleaner ones, and the plastic containers have been segregated from the metals. Also illustrated are some bulk woven plastic containers used to house the shredded plastic containers in Saskatchewan and some of the shredded containers themselves.

Example of a collection site for Agrochemical containers
(Plastics have been seperated in this site)

Same site showing seperated metal containers

Shredded Plastic Agrochemical containers

Bulk storage bags used to inventory shredded plastic and facilitate shipping and handling

SECTION 2

SUMMARY & CONCLUSIONS

This study concludes that the recycling of Agrochemical containers is a viable alternative to incineration as a means of disposing of empty containers.

The key considerations addressed in this study relate to the development and implementation of a successful recycling program in Alberta and are summarized as follows:

By September of 1988, it is estimated that the inventory of plastic and metal containers collected sites throughout the province of Alberta will be in the order of 1.2 to 1.5 million units. Industry sources estimate that the inventory is approximately 70% plastic and 30% metal. In terms of weight, the plastic represents a total of approximately 920,000 to 1,000,000 lbs. and metal in the order of 1.5 to 1.75 million lbs., for a total accumulated weight of approximately 2.5 million lbs. Inspection of a number of collection sites indicate an accumulation in addition to plastic and metal containers consisting of miscellaneous garbage, paper cartons and residual chemical remaining in the containers. In the 1986 collection year, it is reported that there were some 104 permanent collection sites and 100 temporary sites serviced throughout Alberta. There are approximately 140 sites known to be in place. It is further estimated that the return rate for the Agrochemical containers is in the order of 60 - 65%. The return system is on a voluntary basis.

The established collection sites provide a vehicle for centralized accumulation of waste containers. There is however, not in place a practical and economically viable solution to date with respect to the detoxification or disposal of the containers. One of the immediate problems to be addressed therefore, is that of the handling and disposal of the current inventory of accumulated containers.

With respect the collection infrastructure the main problems are related to:

- the lack of disposal alternatives.
- environmental and employee safety concerns.
- the presently inadequate funding methodology

2.1 DECONTAMINATION CONSIDERATIONS

The chemical manufacturers recommend that the contents of the container be completely used in the field and the container be thoroughly rinsed at least three times with a diluent (such as water) and that the contents of this be added to the spray tank as part of the mixture. No assurance can be made that the procedure is always followed. The result is that an accumulation of the chemical residue in the container winds up in the collection site inventory. The movement therefore, of the containers from the collection sites to the final treatment facility is a major factor because of the toxicological properties of the contaminants.

2.2 CONTAINER RECYCLING PROCESS

A process for recycling Agrochemical containers, both plastic and metal, has been conceived based on prior technology developed by Applied Polymer Research for recycling plastic beverage bottle containers. The process involves four steps:

1. Size reduction, draining and preliminary decontamination.
2. Primary washing and liquid treatment.
3. Secondary washing and dry resin clean-up.
4. Pelletizing.

Recovered, pelletized, polymeric material is then present as a reusable polymer for further processing to an end product.

Treating the metal containers, involves shredding, draining and steam stripping. Collected residues are shipped to Swan Hills for incineration, and the recovered metal packaged in bulk containers and shipped to a steel mill for further reuse.

2.3 REUSE MARKET

PLASTICS

High density polyethylene is the principal polymeric material used to produce Agro-

Capital Cost Comparisons Recycling vs. Incineration

	Incineration	Recycling
- shredding (one system only)	$ 251,000	$ 251,000
- washing & wastewater treatment		$ 736,000
- secondary cleaning & pelletization		$ 326,000
- TOTAL	**$ 251,000**	**$1,313,000**

Comparitive Operating Costs Recycling vs. Incineration

	Incineration	Recycling
Plastics	1.03	0.62 - 1.22
Metal	1.18	0.43 - 0.70

Table No. 1

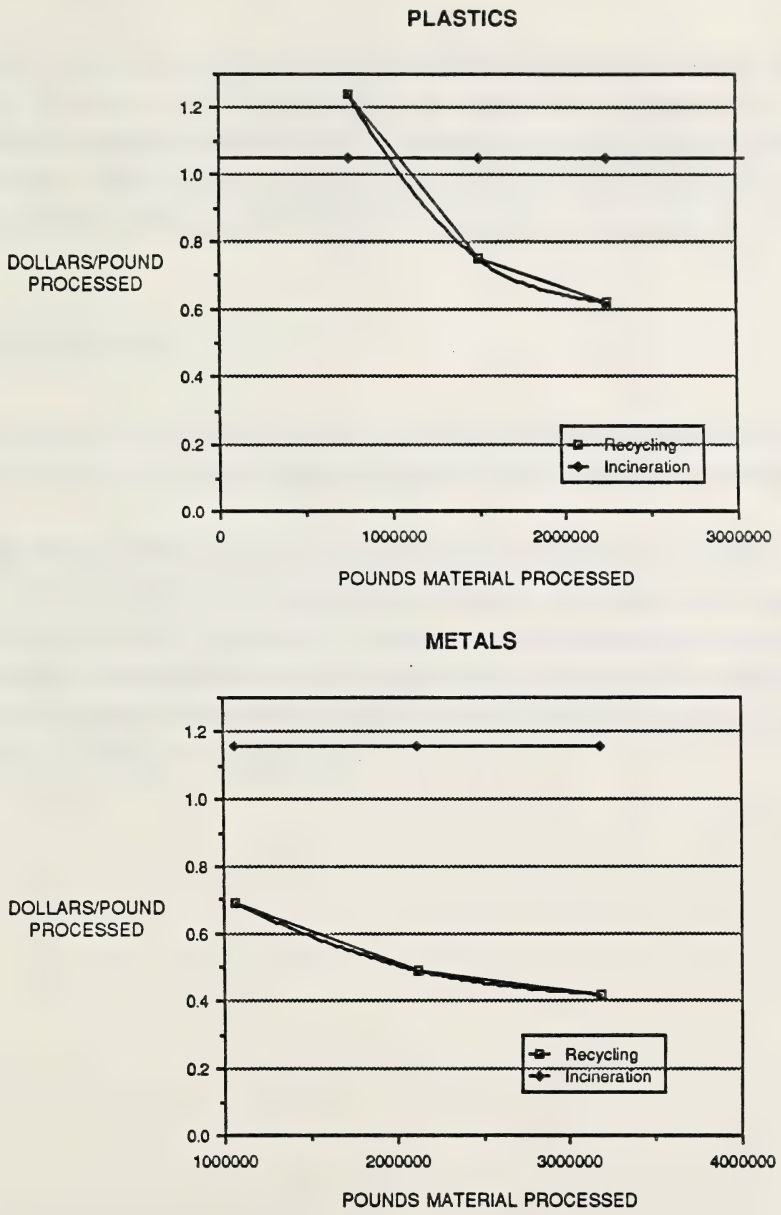


Figure No. 1

Break-even Chart
Operating Costs of
Recycling vs. Incineration

2.5 INDUSTRY ATTITUDES

The Agrochemical industry is itself concerned about this problem of Agrochemical container disposal, and is cooperating to resolve it. Towards this end, the Crop Protection Institute of Canada (CPIC) initiated a meeting in Regina, Saskatchewan on February 24, 1988 to meet with government and industry representatives. The minutes of that meeting are inclosed in this report as Appendix C.

2.6 CONCLUSION

In conclusion, this study indicates that recycling as opposed to incineration provides for opportunity to impart value to the recovered plastic and metal containers.

Although this project was a consulting study, there was some element of research and development related to the assessment of various treatment alternatives for decontamination of the plastic materials. Testing to date indicates that the decontamination of the polymer material for the specific applications outlined above is feasible, however recent development work with regard to the element of further end uses necessitates that further testing be undertaken.

SECTION 3

RECOMMENDATIONS

On the basis of the information presented in this study, the following recommendations are presented to address key considerations toward the resolution of immediate and long term requirements for the establishment of a viable recycling facility in Alberta.

3.1 COLLECTION INFRASTRUCTURE

To resolve the immediate problem for relieving congestion of the collection sites located throughout Alberta so that they may be used once again to accumulate containers from this year's growing season, the waste Agrochemical containers (both metal and plastic) be crushed, shredded and drained of residues, bagged and stored until a viable treatment recycling facility is sanctioned by the Alberta Government.

A minimum of three major transfer shredding stations be established to which authorized and appropriately trained personnel can deliver waste Agrochemical containers for preliminary processing. This operation would constitute shredding and packaging both plastic and metal, and the collection of the residues from the containers.

Construction of skid-mounted permanent shredding equipment be designed, built and moved to the transfer stations for shredding and draining of the residues from presently stockpiled inventories of Agrochemical containers. The use of long term non-portable shredding equipment should be employed for safety and supervisory reasons.

The collected residues from the shredding operations be drummed and shipped to Swan Hills for disposal by incineration.

It is recommended that mobile shredding equipment not be used at the collection sites due to the potential environmental and safety hazards presented by its use.

3.2 ESTABLISHMENT OF A CENTRAL RECYCLING FACILITY

It is recommended that a facility be established where the purpose will be to decontaminate, wash, shred and pelletize the plastic for reuse. The clean plastic can then be utilized as a raw material for manufacturing of various marketable products. The metal would go through a steam stripping operation to remove residues from the containers, and then packaged and shipped to steel mills for recycling.

In cooperation with the Agrochemical industry (CPIC members), government and other concerned institutions, methodology development and toxicological evaluations of recycled materials should be initiated.

3.3 FUNDING CONSIDERATIONS

The principal funding requirements relate to the following areas:

- the operation of the collection and decontamination program, specifically:
    - the establishment of strategically located shredding and transfer sites, owned and managed by the counties and I.D.s, or privately.
    - the establishment of a centralized recycling facility for Alberta.
- the support of on-going research and development with respect to the broader picture of recycling and associated environmental issues.
- the promotion of public awareness and support for the program and its objectives.

In consideration of the foregoing, it is recommended that three approaches or combinations thereof be considered for the funding of the above.

1. A deposit system be implemented along the lines of the Beverage Container Act Legislation.
2. An environmental recycling tax be imposed and managed by the Department of Agriculture.
3. Direct funding from the Agrochemical manufacturers through the Crop Protection Institute of Canada (CPIC), or the polymeric Resin Producers across Canada.

4. Provision of funding by loan guaranties or grants to facilitate the development of Transfer Stations and Recycling facilities in Alberta

The implementation of the above would provide a vehicle for the development of a long-term comprehensive strategy for the abatement of used Agrochemical containers and other potentially environmentally hazardous materials.

3.4 GOVERNMENT & INDUSTRY LIAISON PROGRAM

It is recommended that a board be established with its membership to include all licensed outlets for Agrochemicals sold in Alberta. Executive board members should include representatives of:

- Provincial Department of Agriculture
- Provincial Department of Environment
- Agrochemical Industry
- Occupational Health & Safety
- Recycling Industry

The board's operation should include the collection and administration of the funds generated from the funding sources.

3.5 PUBLIC INFORMATION & EDUCATIONAL PROGRAM

Because of the safety factors involved in handling contaminated waste products it is recommended that an information and education program be implemented to upgrade the capability of those people handling the chemical materials and to ensure that the general public has a better understanding of the program. It is recommended that all employees or individuals handling the chemical containers or end products be informed and trained of the safety aspects and be knowledgeable in the requirements of the upcoming Work Place Hazardous Materials Information System (WHMIS) guide-lines. The new WHMIS guide-lines will be in effect November 1, 1988, and are included in Appendix B of this report.

.6 *RECYCLING DIVERSIFICATION PROGRAM*

t is recommended that in order to further improve the economics of the recycling rocess, and for the benefit of our environment, that the implementation of recycling or other types of compatible containers be incorporated into this process. Other otentially recyclable containers using the plant proposed for the purpose of recycling grochemical containers would include oil bottles, bleach bottles, plastic milk bottles, nd some types of detergent bottles.

SECTION 4

DEFINING THE PROBLEM

Since World War II, the plastics industry has experienced phenomenal growth because of the desirable properties of plastics. Although plastics are being used today in a broad range of consumer products, a major portion of the resin is being converted into products having shorter intermediate life spans - thereby creating a problem. Plastics are virtually indestructible, unaffected by air, water, chemicals and bacteria and many are even stabilized against heat and light. Unlike many other items of refuse, they do not easily degrade. Plastics are therefore most difficult to dispose of - they are discardable, but not disposable. The problem of disposal is appropriately referred to as "Plastic materials - wonder substance of the 20th century - environmental headache of the 21st". Similarly, metal containers also pose problems. They currently compose roughly 30% by volume of the Agrochemicals sold in western Canada, and although they have been recycled at Steel mills in the past, reluctance to accept these containers in the future has been expressed.

Because of the foregoing concerns, the need for answers for this whole Agrochemical container issue has emerged. The Alberta Department of Environment has during the last several years addressed this problem of recycling waste plastic chemical containers to the extent that the first steps in a collection infrastructure have been established. With the establishment of the Alberta Special Waste Management Corporation's facility at Swan Hills, a vehicle is presented for disposing of the containers and their attendent chemical residues by incineration.

Estimates place the current inventory of waste agrochemical containers at collection sites throughout Alberta at some 2,000,000 - 2,500,000 pounds, and 1,000,000 - 1,500,000 pounds in Saskatchewan. A similar problem exists in Manitoba, and to a lesser extent in B.C. - the problem of disposal of this potentially hazardous group of plastic containers is therefore spread across the whole of the Western Canadian Provinces.

As land fills become more difficult to situate and expensive to maintain, and their numbers begin to decrease, municipalities and industries are starting to take a new

look at alternatives to this disposal problem. This study has been undertaken to consider these alternatives to landfilling - incineration, and recycling.

4.1 OTHER CONCERNS

In addition to the problems presented by the vast number of Agrochemical containers in use and the resources and costs required to dispose of these, there are other problems at the user level which can be classified into three general areas:

1. **Handling Hazards**
2. **Environmental Concerns**
3. **Contribution to the Litter Problem**

Let us consider each:

HANDLING HAZARDS

"Empty" Agrochemical containers (although strictly speaking there can be argued that there is no such thing as an empty container - there will always be residues of varying strengths and amounts remaining) can be hazardous. Depending on the original material, the residue can in some instances be extremely toxic. Several recorded incidents where individuals have died because of exposure to material from "empty" Agrochemical containers have been recorded in North America. The accidents were the result of improper handling of containers, the reusing of containers or general disregard for the hazards that exist.

ENVIRONMENTAL CONCERNS

Residues from containers dumped along ditches or creek banks can wash into surrounding water systems or even leach into ground waters. Agrochemical containers and cartons burned improperly can cause a drift of volatile herbicides resulting in injury and damage to valuable nearby crops as well as adding to the general air pollution problem.

LITTER PROBLEM

Because of the vast quantities of material involved and currently inadequate methods of disposal, containers often accumulate in areas such as roadsides, open dumps, open lots, etc. The marketing success of a particular brand of pesticide then becomes an embarrassment and a principal source of exposure to the manufacturer. Because of today's environment and ecological concerns pressure is high to resolve this problem.

SECTION 5

OVERVIEW - RECYCLING OF AGROCHEMICAL CONTAINERS

Section 1 points out the five basic criteria for developing a successful recycling program. Again, these are:

1. A continuous source of material.
2. A reliable collection infrastructure.
3. Adequate decontamination technology.
4. Identification and creation of end products for recycled materials.
5. Viable economics.

These criteria are illustrated in Figure 2. This study provides an overview of the foregoing criteria.

5.1 SOURCE OF WASTE PLASTIC CONTAINERS

Pesticides can be defined as those agents used to destroy pests. The term 'pests' refers to many forms of life that are undesirable to man including weeds, insects, bacteria, rodents and fungi. Categorically, these are listed as herbicides, insecticides, rodenticides, and fungicides. In the context of this study, pesticides (including herbicides and insecticides) and other Agrochemical products are referred to collectively as "Agrochemicals". While Agrochemicals may generally be considered as deadly poisons, these chemicals are safe to mankind when used according to label directions. They are toxic to some living forms by their very nature and are produced and used for this reason - if they were not toxic they would not satisfy their intended purpose, and they must therefore be handled with respect. In the summer of 1988, it is estimated that there will be in inventory approximately1,200,000 containers located in collection sites throughout the province of Alberta. Of this number, plastic containers represent approximately 70% by volume, and metal 30%, so with average weights of one pound and four pounds respectively, these numbers mean approximately 840,000 pounds of plastic, and 1,440,000 pounds of metal.

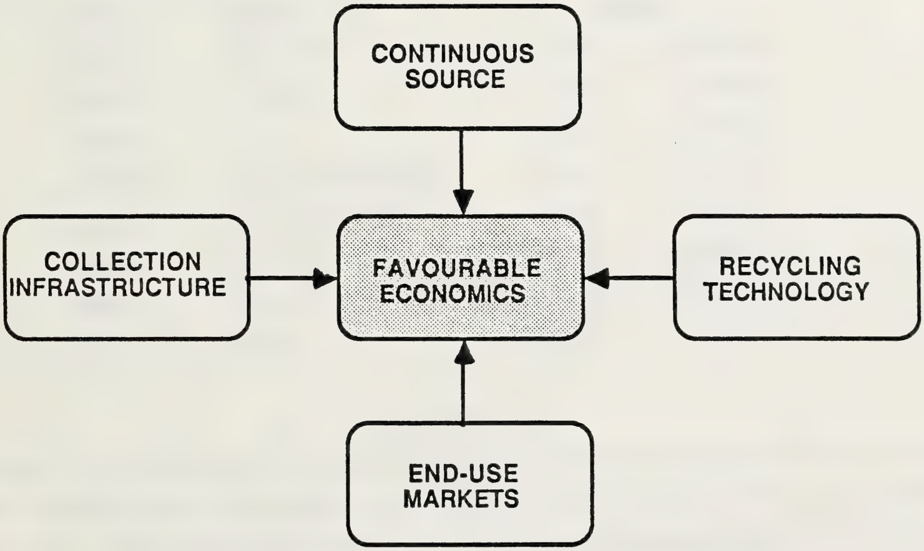


Figure No. 2: The Five Criteria for Succesful Recycling

Industry sources indicate that breakdown by container size of plastics used for packaging Agrochemicals are as follows:

- 10 litre containers - 80%
- 500 g, 1 litre, 5 litre, and 20 litre containers - 20%

Table No. 1 outlines the breakdown of the weight of plastic for each container size for the various Agrochemical products currently in use in Western Canada. Typical masses of empty containers including caps are:

Type	Size	Mass	
plastic	500. mL	119 g	0.26 lb.
plastic	2. L	84 g	0.19 lb.
plastic	4. L	159 g	0.35 lb.
plastic	10. L (untreated)	366 g	0.81 lb.
plastic	10. L (treated)	416 g	0.92 lb.
plastic	20. L	1331 g	2.93 lb.
steel	20. L	2374 g	5.23 lb.
steel	200. L	29510 g	65 lb.

Table No. 1

Industry further reports that the ratio between herbicide and all other pesticide containers is approximately 80:20, and there is a total of in excess of 2,500,000 pounds of plastic used in packaging Agrochemicals annually in Western Canada (ie 1,250,000 pounds in Saskatchewan; 500,000 pounds in Manitoba; 750,000 pounds in Alberta). This volume is projected to increase by replacing metal which has historically been the material used for packaging agrochemicals.

6.2 COLLECTION INFRASTRUCTURE

The Department of Environment has developed a program for the collection of the chemical containers by establishing a series of collection sites throughout the province. As of the end of 1987, there were some 104 permanent collection sites in Alberta and approximately 100 temporary sites. The locations of these sites are outlined in Figure 3.

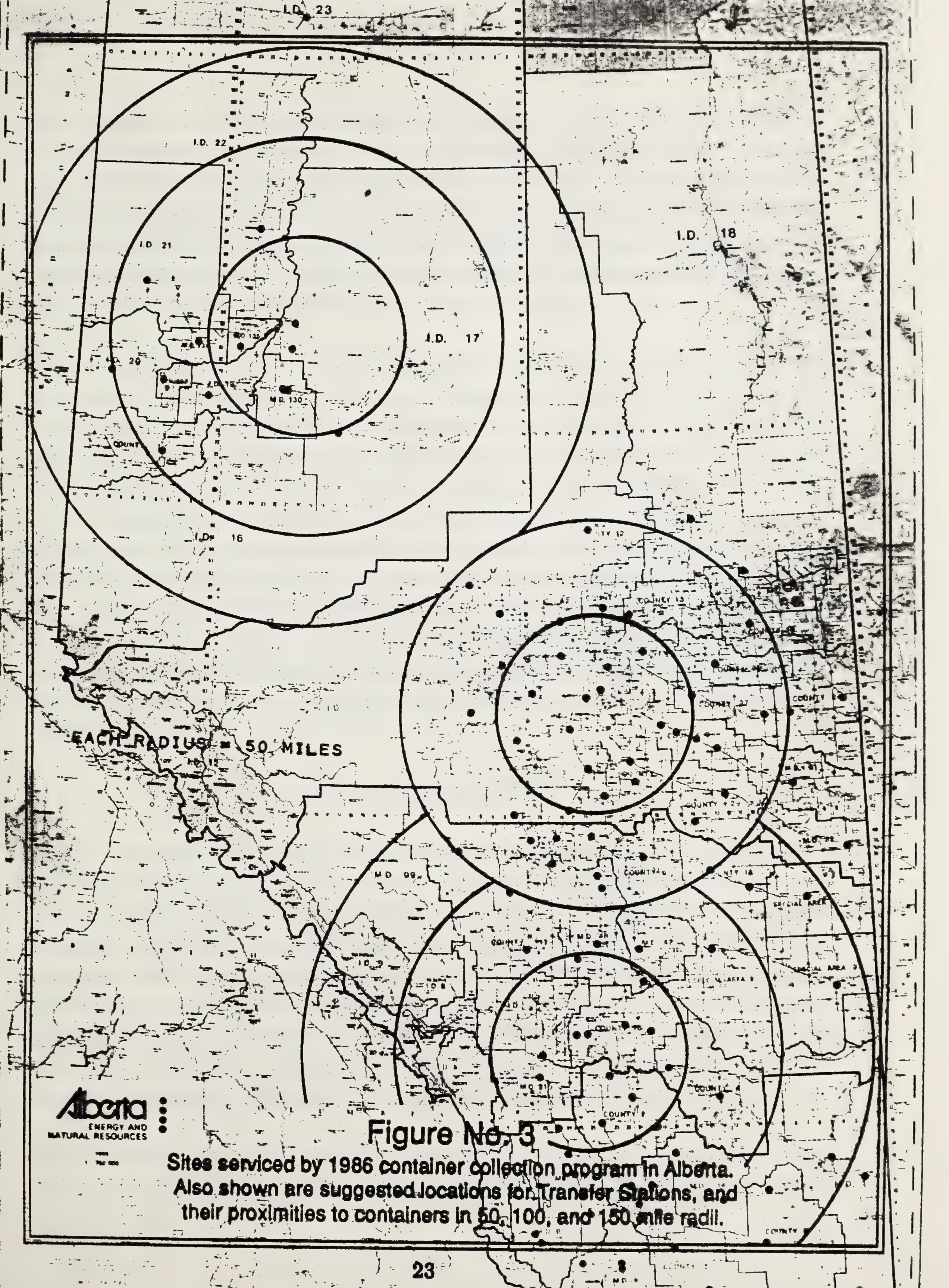


Figure No. 3

Sites serviced by 1986 container collection program in Alberta. Also shown are suggested locations for Transfer Stations, and their proximities to containers in 50, 100, and 150 mile radii.

This network of collection sites was established by communities across the province to receive Agrochemical containers returned for disposal. While it is extremely difficult to establish the recovery rate, it has been estimated at 60 - 70%. Inspection of a number of these sites has indicated that the accumulation at the sites includes plastic containers, metal containers, miscellaneous garbage, and paper cartons used to package the containers for shipment from the supplier to the farmer. At this time, the return system for the empty containers is purely voluntary.

While this establishment of collection centres has provided a vehicle for centralized accumulation of the containers, a practical or economically viable solution has not yet evolved with respect to detoxification or disposal of the containers. During the early 1980's, the Alberta government experimented with a program whereby the containers were crushed and shredded and the plastic containers shipped to Kinetic Resources, Nisku. Attempts were taken to wash the plastic material and recovered it for reuse in extrusion operations, but this did not prove to be a viable alternative, primarily because of detoxification limitations with respect to end use markets. The collected residue was dumped into landfill sites, and scrap metal recovered was sold to steel companies for reuse in smelting operations. In the past, landfill has been considered one of the basic approaches for plastics disposal however landfills are difficult to maintain and locate, and the Alberta Government has recently ceased the practise of landfilling used Agrochemical containers.

NEED FOR INCENTIVE

Alberta Government's Beverage Container Act of 1975 encourages the end user to participate in the recycling and disposal program. This legislation has been particularly successful with the recycling of beverage containers produced from metal, glass and plastic, achieving very high return rates. Obviously, this type of recycling system involves additional costs probably to be passed on to the consumer, and would require the involvement of the chemical manufacturers in supporting this type of program. Unfortunately, the safety aspects of handling used Agrochemical containers precludes the return of this type of container for return of deposit, as this type of system may encourage improperly trained personnel (ie. Boy Scouts) to do this.

Since the collection of the containers represents a major economic consideration, resolution to this problem requires a cooperative approach from industry, government, and end users.

5.3 DECONTAMINATION TECHNOLOGY

Ideally, decontamination of Agrochemical containers should begin in the field where the product is used. In this regard, chemical manufacturers recommend that the entire contents of the container should be used and applied as directed according to the intended use, observing the safety precautions outlined on the container label. They further recommend that the container be rinsed thoroughly (at least three times with a diluent (water)) and added to the contents of the spray tank as part of the agrochemical mix. The foregoing procedure should then be followed by closing all the openings tightly and the outside of the container rinsed to remove any chemical material that might have spilled along the sides or top. Following the foregoing, the containers are then in a condition to be moved to collection/storage sites. For all good intentions this procedure is not always followed, which results in a great accumulation of residues in the containers encompassing a broad range of mixtures of Agrochemicals. In general terms there are two approaches to handling the contaminated containers. The first is incineration of the container and contents, including the movement of the containers to Swan Hills in shredded form, packed in drums ready for handling and subsequent destruction by incineration. An alternate method is to wash the container with a suitable solution to bring the container to a point where the plastic material can be reused for conversion to another product. The chemical residues collected could be transported to Swan Hills for incineration.

5.4 REUSE OF MATERIALS

A conceptual process for recycling polymers from the decontamination of agrochemical containers generates colour mixed granulated high density polyethylene. When the resin is sufficiently clean, its impurities removed and pelletized, current market value is in the order of $.15 - $.18 per pound.

Markets for recycled polyethylene from this source would be limited to non-food applications. Examples include blow-molded horticultural pots, extruded sheet for thermoforming of nursery trays, and production of woven and non-woven fabrics in geo-technical applications.

Metal pails and drums used to contain Agrochemicals can be recycled at the steel mills, where it is incorporated into the general population of other "shredded scrap". This

"shredded scrap" is added in varying proportions to other steel, and used to make angle iron, flat bars, re-bar, ball stock, grader blades, small channels, sucker rods, and other products.

5.5 ECONOMIC CONSIDERATIONS

Economics must consider the following key components for comparisons between the two alternatives to container disposal:

	Incineration	Recycling
• collection	√	√
• shredding	√	√
• intermediate packaging (to accomodate transport or handling requirements)	√	√
• processing	√	√
• end-use	-	√
• disposal	√	-

Table No. 3

SECTION 6

REVIEW OF THE SOURCES AND COLLECTION INFRASTRUCTURES FOR AGROCHEMICAL CONTAINERS

6.1 INTRODUCTION

Agrochemicals have become integral components in commercial food production. They are for the most part composed of an organic base with halogen, phosphate, or sulphonate groups, or combinations of these. Advances in organic chemistry during the past two or three decades have made it possible to fabricate molecules of the aforementioned chemicals into a multitude of configurations, all of which have properties that make them unique in some way. For example, certain of these combinations are "broad band" pesticides which can be used to control a variety of plants or animals (for example, 2, 4- D which can be used as a general herbicide to control all broad-leafed plants). Other such chemicals have been designed to target a single species of plant or animal (for example, wild oat herbicides).

In nature many of these compounds, in fact the bulk of them, can be neutralized by exposure to ultraviolet light, and others can be rendered harmless by bacterial action in the soil.

6.2 MANUFACTURERS & DISTRIBUTORS OF AGROCHEMICALS IN CANADA

There are about 145 companies which presently distribute Agrochemicals in Canada. The bulk of these companies do not manufacture these products, but act as formulators and distributors for the manufacturers of the active ingredients. Almost all of the active ingredients forming the basis for agrochemical production in Canada are manufactured outside of Canada, primarily in the United States, France and Great Britain.

The following companies account for virtually all of the agrochemicals distributed in this country*:

1. B.A.S.F Canada Inc.
   10 Constellation Court
   Rexdale, Ont.

   U.S. owned; active ingredients made in U.S.A.

2. Baynet Division
   Miles Laboratories Ltd.
   77 Belfield Rd.
   Rexdale, Ont.

   U.S. or British owned; active ingredients from parent company

3. Chevron Chemical (Canada) Ltd.
   3228 South Service Rd.
   Burlington, Ont.

   U.S.. plant; active ingredients from U.S.

4. Chipman Inc.
   Box 9910
   400 Jones Rd.
   Stoney Creek, Ont.

   I.C.I owned; English and U.S. parent supplies active ingredients

5. Ciba-Geigy Canada Ltd.
   Agricultural Div.
   6860 Century Ave.
   Mississauga, Ont.

   Active ingredients from outside Canada

6. Dow Chemical Canada Inc.
Box 1012, Modeland Rd.
Sarnia, Ont.

U.S. parent; U.S. source for active ingredients

7. Dupont Canada Inc.
Box 2300, Streetsville
Mississauga, Ont.

U.S. owned; active ingredients from U.S. parent

8. Elanco Division
Eli Lilly Canada Inc.
3650 Danforth
Scarborough, Ont.

U.S. owned; active ingredients from U.S.

9. Hoechst Canada Inc.
Agriculture Div.
295 Henderson Drive.
Regina, Saskatchewan

10. May and Baker Canada Inc.
6557 Mississauga Rd.
Mississauga, Ont.

Recently purchased from Union Carbide, parent company, France and Britain are source of active ingredients.

11. Monsanto Canada Inc.
Agricultural Products Div.
55 Murray Park Rd.
Winnipeg, Man.

U.S. owned, active ingredients from U.S.

12. Rohm and Haas Canada Inc.
2 Manse Rd.
West Hill, Ont.

13. Sandoz Agro Canada Inc.
Suite 302, Plaza 4
200 Argentia Rd.
Mississauga, Ont.

Swiss owned, active ingredients from U.S.

14. Uniroyal Chemical
Box 250, Erb St.
Elmira, Ont.

U.S. owned, technical chemicals from U.S.

(* see "Pest Control Canada", a reference manual, 1987, published by PACS, 3425 Harvester Road, Suite 202, Burlington, Ont.

Of the 145 different companies distributing agrochemicals in Canada, 23 (including 8 of the 14 listed above) operate formulating plants in Canada.

The 12 most heavily used Agrochemical products in Alberta are listed in Table No. 4.

Active Ingredients	Trade Name
1. Trifluralin	Treflan
2. Diclofop-methyl	Hoe-Grass
3. MAA, MAB,MAE,MAS	MCPA
4. 2,4-D	(various names)
5. Trifluralin	Rival
6. Bromoxynil, MCPA	Buctril-M
7. Triallate, MCPA	Avadex
8. Sethoxydim	Poast
9. Bromoxynil, MCPA	Sabre
10. Bromoxynil	Torch
11. Clopyralid	Lontrel
12. Glyphosate	Round-up

TABLE No. 4

6.3 PLASTIC AGROCHEMICAL CONTAINER MATERIALS

Discussions with Crop Protection Institute of Canada (CPIC) members have revealed that these containers are made almost exclusively of high density polyethylene (HDPE), some with a fluorination treatment, and some with a Nylon coextrusion. In Europe, pesticide formulators have agreed collectively to use HDPE containers exclusively for packaging of their products, and similar action is being considered in North America.

Some of the main suppliers in Canada for these containers are Reliance Manufacturing, Vulcan Packaging, ABC Packaging, and Rheem Canada. Typical methods used to manufacture these containers include blow-molding and injection molding.

6.4 COLLECTION SYSTEMS

OVERVIEW

A glance at the North American scene reveals that systems set up to collect waste plastics of any kind let alone Agrochemical containers are rare indeed, and when they do exist, are invariably either government-funded or their funding is legislated in some manner by governments. A review of the EPA proceedings of the "National Workshop on Pesticide Waste Disposal" (Denver, Colorado; September 1985) and the proceedings from the "National Workshop of Pesticide Waste Disposal" (Denver, Colorado; January 1986) reveals thatthere has yet to be devised a suitable collection system for Agrochemical containers at this time. In fact, the collection system set up and funded by the Alberta government received considerable attention at these conferences because it is one of the very few systems operating in North America.

The state of Maine has a system used to track container usage based upon a highly detailed and complex registration mechanism requiring a $5.00 deposit from purchasers of Agrochemical containers of less than 30 gallons and a $10.00 deposit on containers of greater volumes. While it appears that this system is relatively successful in its operation, the contaminated waste plastic collected makes up a very small percentage of the amount of plastic in their waste stream and may not be extrapulatable to Alberta. What the Maine system does demonstrate however, is the fact that those purchasing Agrochemicals are willing to pay an amount over and above the actual product cost to fund a collection program.

In discussions with waste management personnel in Manitoba, B.C. and Ontario, it was revealed that there is not currently a system in any of these provinces to collect Agrochemical containers. B.C. has introduced legislation that in 1988 will place waste Agrochemical containers into a hazardous waste category.

THE ALBERTA SCENE

Alberta's establishment of Agrochemical container collection sites has been a very progressive step towards finding a solution to the collection problem in that it encourages good practises on the part of the farmer since they have become accustomed to the practise of depositing his containers at the site, a very important step required for

container collection. Saskatchewan has adapted a similar procedure for shredding in the field, and safety does seem to be a concern here as well. Much better supervision is recommended in order to ensure that:

1. Personnel working in the collection system remain in good health (both from the point of view of minimizing or eliminating their exposure to the contaminants, and from being injured or killed in accidents using the grinding and shredding machinery).

2. The general public is also ensured protection from the contaminants emitted from the cleaning and recycling processes.

In Alberta at present, the actual collection of waste Agrochemical containers has been discontinued and the containers are being inventoried until further consideration can be given to:

1. What other collection options can be implemented.
2. What the final destination for the contaminated containers might be.
3. How the system to collect the containers might be funded using a minimum of taxpayer dollars.

The situation is pressing because the agricultural community is continuing to bring waste Agrochemical containers to the local drop-off points which in turn, are becoming overcrowded and thus unusable.

Bearing in mind that:

a. The contents of the waste Agrochemical containers and the containers themselves are contaminated and must be regarded as unsafe;

b. Personnel involved in the handling and collection of these containers should be required to have a certain amount of basic training in handling this material and in operating machinery used in the process;

c. To ensure that the environment and those working with the containers are not endangered in any way, safety must always be the main consideration in

collecting an decontaminating these containers and the materials derived from them.

Every effort should nevertheless be made to:

i) economize wherever possible without reducing the safety factors involved and,

ii) seek methods of recycling the metal and plastic from which the containers are made after this material is decontaminated to turn the material into saleable products, removing it from the waste stream for long periods of time (forever, if possible) and to treat, neutralize, destroy, or in some way render harmless the contaminated wastes resulting from the clean-up and reuse of waste metal and plastic from the recycled containers.

6.5 POSSIBLE COLLECTION OPTIONS

It is proposed that the user of the Agrochemical should continue to take the waste containers to the approved local collection or drop-off point. This is a fundamental requirement which must remain in place for any collection system. From this collection site, their are a number of options available for further processing of Agrochemical containers. The options available for collection of the containers from the sites and the primary size reduction (shredding), including packaging into suitable containers for transport to a final processing site are discussed in the following paragraphs.

OPTION "A"

The waste Agrochemical containers collected and stored in sites throughout Alberta are delivered intact and unprocessed to a central location where they will be shredded, drained, and packed into containers suitable for either interim storage, future treatment (recycling), or shipment to Swan Hills (incineration). This alternative should only be used once and only if absolutely necessary to address the immediate need for providing storage space for this year's incoming waste containers. The economics for this method are not attractive because the unshredded containers weigh very little

in comparison to the large amount of space that they would occupy in transit. The waste containers will make this initial trip whole. That is, they will not have been crushed, shredded or compacted in any way, assuming that Alberta's present moratorium on shredding of Agrochemical containers in the field does not allow this.

OPTION "B"

This scenario is similar to option "A" above, however the containers would be shredded in the field at the individual collection sites, similiar to the system used presently in Saskatchewan. The shredding equipment however, would be designed specifically forportable use, and would not be a modification of existing machinery. This would prove for a much safer operation with the crews chosen for this task fully trained to recognize the risks involved in the operation, and adequately supervised.

Chemical residues recovered in this operation would be collected, drummed, and shipped to Swan Hills for disposal. The metal and plastic containers would be shredded and packed into containers suitable for transport to a central handling facility.

OPTION "C"

This option represents a variation on the above, but the containers would be hauled from the collection sites intact and brought to an intermediate 'Transfer Station" located within an economically viable distance from the collection sites - refer to Figure No.2, Section 3. Shredding of the containers would take place at the stations using non-portable skid mounted equipment with the processed containers and their residues moved by approved hauling equipment to a facility for final treatment of the material.

In an area the size of Alberta, it would be economically advantageous to upgrade two or three of the 145 odd collection sites in southern and central Alberta and perhaps one in the Peace River/Grande Prairie area as "Transfer Stations". At these stations, the contents of perhaps 48 or 50 sites could be accumulated over the summer and early autumn by a crew of people trained for this purpose. A crew of trained personnel equipped with proper technical back-up could then locate at the site for a period of time, during which they would reduce the volume of the waste containers, collect the residues from the shredding operation, and pack the solid materials into containers suitable for either interim storage, or further treatment.

These sites would require capital expenditures to set them up in a permanent fashion and would be capable of handling both plastic and metal containers. The ground plastic would be contained in high strength woven one tonne bulk plastic bags double lined with polyethylene bags if destined for either interim storage or recycling, or packed into 200 L drums if destined for Swan Hills. The bags used to transport the ground plastic would be tied at the top and folded inside the woven container which would then itself be tied off. The shredded, semi-processed materials would then be sent to a recycling or incineration facility. This system would allow for far more economical movement of the material and accompanying contaminants to the final processing site where it could be stored safely while awaiting processing. The liquid contaminants leaking out during the shredding process would be captured and contained for either shipment to the Swan Hills facility, or stored for further treatment.

OPTION "D"

Regional intermediate processing sites similar to those in Option C, could be established throughout the province where Improvement Districts, Counties, and municipalities employing their current waste collection infrastructure, would haul all contaminated waste Agrochemical containers. Administration of these sites would be undertaken by the local authorities themselves. These sites could be set up to shred and drain the containers, with the chemical residues collected for shipment to Swan Hills or other treatment facilities. The shredded plastic and the shredded metal would be shipped to a final recycling and treatment facility.

This alternative appears to be preferred by both Environment personnel and Waste Management personnel from the Counties, Municipalities, and Improvement Districts, as the opinions expressed indicate that such sites initially established for the handling of contaminated wastes, can be easily expanded to become regional recycling centres owned and operated by the private sector .

The strategic staging area concept will provide two important items which currently are not present in the systems used in either Alberta or Saskatchewan. These are:

a. Because of the permanent or semi-permanent nature of the Transfer Stations, the site itself can be engineered to capture and contain contaminants which can then be removed for treatment or destruction.

b. The fact that only two or three of these facilities might be required means that processing large amounts of these containers at these sites will require longer periods of time at the same site. This will promote the use of better equipment and a crew which can be more easily supervised and therefore more susceptible to better operating and safety conditions. These personnel should be well-trained in safety and better equipped for the job than those observed in Saskatchewan.

Disposal for plastic containers in Saskatchewan has until recently occurred by shipping shredded plastic in bulk containers to landfill sites where the materials were buried, and in Alberta, the system was similar. In both provinces, metal containers - either shredded or crushed - were compacted inside automobiles or otherwise destined for smelting in local steel mills.

Until last year, both provinces ground the containers on site, a process which has since been abandoned in Alberta because of the death of one worker and injury to another. In Saskatchewan, this system is still employed, but an on-site inspection by APR personnel revealed that worker safety is a MAJOR concern.

A comparison of the three collection alternatives is illustrated in Table No. 5 and Figure No. 4.

6.6 FUNDING OF THE COLLECTION SYSTEMS

The current method of funding Alberta's beverage container collection system is based on a legislated deposit system covering all beverage containers. The consumer pays a deposit on the container at time of purchase and receives it back when the container is taken to a bottle depot. The bottle depots obtain their funding from the beverage manufacturers in the form of a handling fee on a "per bottle" basis. This handling fee is a cost to the beverage manufacturers, and subsidized by unreturned container revenues.

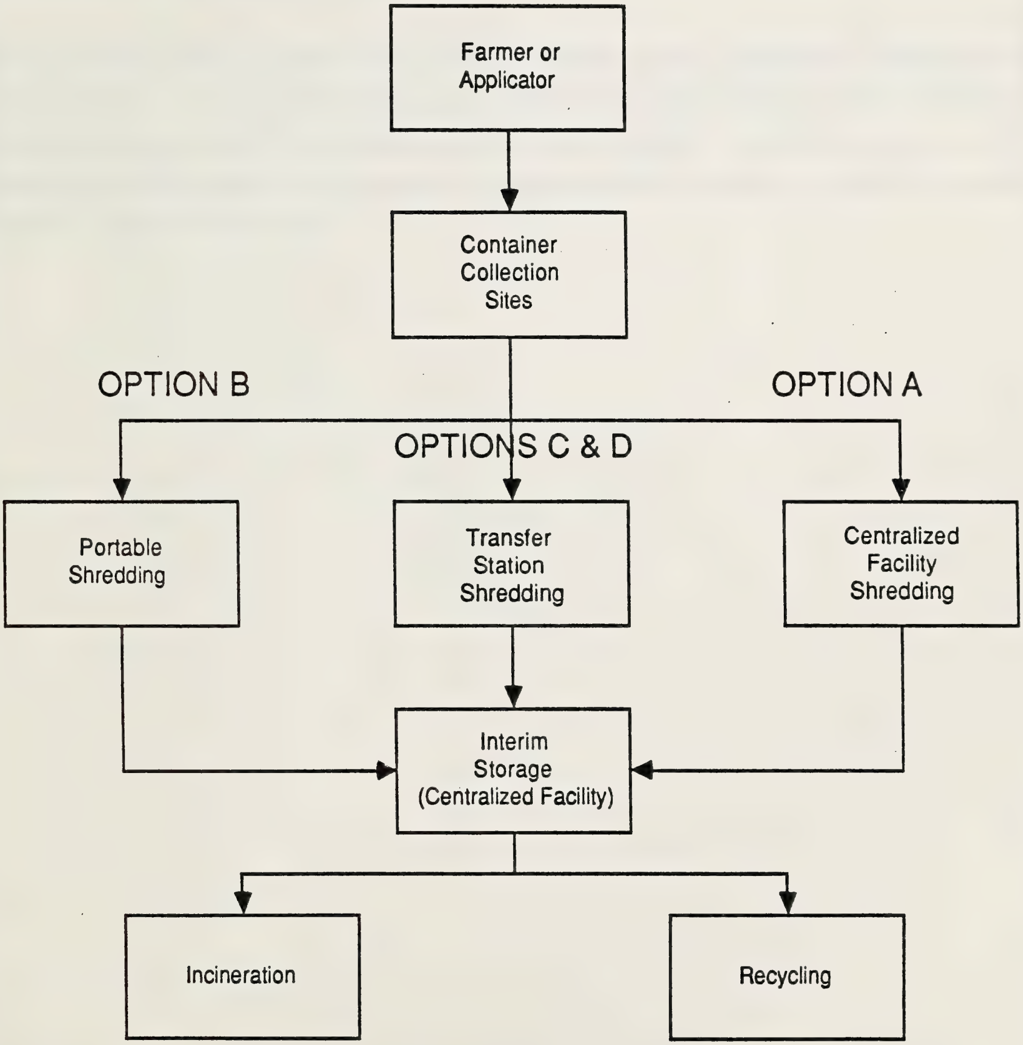
The Agrochemical Container Collection System in Alberta (and Saskatchewan) is at this time, funded 100% by the provincial government. As the provinces no longer wish to assume financial responsibility for this problem, they are proposing change. In the past metal containers have been more recyclable, but even this is now in jeopardy, as

A COMPARISON OF COLLECTION ALTERNATIVES

	A	B	C	D
• container shredding occurs:				
on-site	-	√	-	-
transfer sites	-	-	√	√
central facility	√	-	-	-
• transportation to shredding facility of:				
whole containers	√	-	√	√
woven bags	-	√	-	-
drums	-	√	-	-
• number of shredding facilities is:				
	1	2-3	2-3	10-12

Table No .5

A COMPARISON OF CONTAINER COLLECTION OPTIONS


Farmer or Applicator
Container Collection Sites
OPTION B
OPTION A
OPTIONS C & D
Portable Shredding
Transfer Station Shredding
Centralized Facility Shredding
Interim Storage (Centralized Facility)
Incineration
Recycling

Note: Option C is administered by contractors, Option D by the Counties or I.D.s.

Figure No. 4

health concerns for steel workers have been raised by their unions. The Agrochemicals remaining in metal containers are destroyed during the smelting process by the very high temperatures required to melt the metal and through the use of Bessemer type furnaces for increased residence time. Open hearth type furnaces do not allow sufficient retention times for complete destruction.

It is therefore in the interests of the plastics industry, the Agrochemical industry, the agricultural community, and the taxpayers of Alberta (and Canada) to develop methods to collect, recycle and manufacture new products from the recycled containers, and to treat, neutralize or destroy the wastes resulting from the process in an environmentally sound, economical manner.

SECTION 7

CONTAINER RECYCLING PROCESS OPTIONS

This section deals with the alternative treatment methods for recycling Agrochemical containers and proposes a conceptual process flow diagram for the handling of the containers.

7.1 GENERAL CONSIDERATIONS

There are many ways in which plastic containers can be recycled. A very basic sequence would include collection of the containers, reduction of their particle size, cleaning of the particles, and formation into a new article. Pesticide containers, because of their toxic nature impose limitations and variations on these steps. Pesticides are very complex chemical solutions, specifically formulated to kill non-wanted pests or varieties of plants. Recent advances in pesticide formulating has seen progress towards the development of very species-specific solutions, allowing for reduced damage to beneficial crops or insects. Pesticide formulations, and therefore treatment technologies for decontamination vary widely from one pesticide to another. As a condition of registration with the federal government under the Pest Control Products Act (required to sell pesticides in this country) First Aid, Disposal, and Decontamination procedures must be filed with the commission. This requirement would at first glance, seem to solve most problems associated with the recycling of this material, however they are not as helpful as it might first appear. An example of this are the instructions taken off of a 'Target' container. These instructions are typical of those found on containers of this type, and read as follows:

First Aid Instructions:

> If on skin, wash with soap and water. If in eyes, flush with clear water for 15 minutes. If swallowed, induce vomiting. Obtain prompt medical attention.

7.2 OVERVIEW OF RECYCLING PROCESS

The process for recycling agrochemical containers involves four steps. These are reviewed in the order in which they are carried out:

STEP1. SIZE REDUCTION, DRAINING & PRELIMINARY DECONTAMINATION

The first step in the process begins by feeding the whole containers to a hopper located over a shredder which reduces the container to a series of strips of plastic and/or metal to 1/2" - 1" (width) by 3" - 4" (length). If the containers are received in an already shredded form, they by-pass this step.

The shredded material is deposited on a perforated belt conveyor to allow the residual agrochemical liquids to drain free of the shredded parts. This step is followed by steam stripping of the chemical from the shredded material.

The shredded plastic/metal is then dried with the plastic passing through a cyclone to remove paper or other light particles.

The metal containers when run, would be diverted to a bagging stand and containerized prior to being sent to Stelco for recycling.

STEP 2. PRIMARY WASHING & LIQUID TREATMENT

The granulated flakes of plastic are added to a wash tank, which is heated to approximately 65°C, is constantly agitated, and has a cleaning solution added to it. The cleaning solution would be composed of surfactant, caustic soda, bleach, and detergent. After a residence time of approximately 2 - 3 minutes, the slurry is then pumped through a hydrocyclone - the polyethylene is carried out in the overflow, and the rest of the mixture is carried out in the underflow. The overflow is pumped onto a slurry shaker, and the PE discharged into a screen washer, the first step of the secondary washing process.

The water recovered from the slurry shaker is added to the water taken from the underflow and constantly fed to a belt type filter which removes particulate contaminants from the mix. This filtered mixture is bled from the filter and passed through a treatment system, then added to a hold tank. The water level in the mix tank is maintained by the addition of water from the secondary hold tank. When this level has been lowered, its level is maintained by the addition of water from the treatment system. Particulate matter recovered via the particulate filter is added to the sludge recovered from the oil/water demulsifier in the treatment system and sent to Swan Hills for disposal. At the end of the day, the liquid in the primary hold tank is run through the treatment system, the wash tank is filled, and the remainder of the liquid stored in the secondary hold tank before addition to the wash tank the next day.

STEP 3. SECONDARY WASHING & DRY RESIN CLEAN-UP

The screen washer is fed with fresh city water, counter current to the material flow. The resin flows from the spin dryer into a fluidized bed dryer where the resin undergos final drying and the fines, and any remaining paper labels are blown off and collected. It is anticipated that these materials will be suitable for ordinary landfill sites. The material is then pelletized, the final stage of the procedure.

Water from the screen washer is combined with the flow from the spin dryer, and held in a storage tank until it is run through the treatment system. The effluent from the process is returned to the process as make-up water, and the rest is discharged down the city drain (the volume is expected to be very small: only 2-3 gpm from the addition of city water the screen washer, less make-up).

STEP 4. PELLETIZING

Pelletizing of the material is necessary to further filter the material so that it is capable of being utilized in a blow molding operation. As well as this, additives can be incorporated into the melt to improve the properties of the polymer. Examples of additives which may be necessary depending upon the material's intended end-use include colourants, anti-oxidants, UV stabilizers, and anti-slip agents.

7.3 FLOW DIAGRAM

Considering the foregoing, a simplified block flow process diagram is set out in Figure No. 5.

7.4 WASH WATER & RESIDUE TREATMENT TECHNOLOGIES

Because of the nature of this mixture, treatment options are limited. One of the best methods for ultimate destruction of pesticides is controlled **Thermal Destruction.** Other treatment options include **Adsorption, Biological Degradation, Photodecomposition**, and **Filtration**. Each of the foregoing is reviewed in the following paragraphs.

A. THERMAL DESTRUCTION

Thermal techniques work very well to destroy pesticide residues - at temperatures in excess of 1200°C, in the presence of excess oxygen, emissions are limited to standard combustion by-products (carbon dioxode, and water) and other elementary species. Specialized conventional incinerators are most commonly used for this type of application, but other methods are possible, including Molten Salt Combustion, Wet Catalytic Oxidation, and others. With catalytic processes, processing temperatures can be reduced to as low as 300°C. The main limitations with these processes are their inherently high capital and operating costs.

B. ADSORPTION

Adsorption is a process whereby a contaminated feed stream is passed through a bed of specially prepared media, capable of adsorbing contaminants out of the stream. This is achieved through the choice of a material has a greater affinity for the contaminant than does the liquid. In the case of inorganic contaminant removal, (ie. deionization) synthetic resins are usually chosen. For organic contaminant removal, granular activated carbon (GAC) is the norm. Preliminary research suggests that GAC will work well for this application. Additionally, there are a number of historical reasons that its use is suggested. These are:

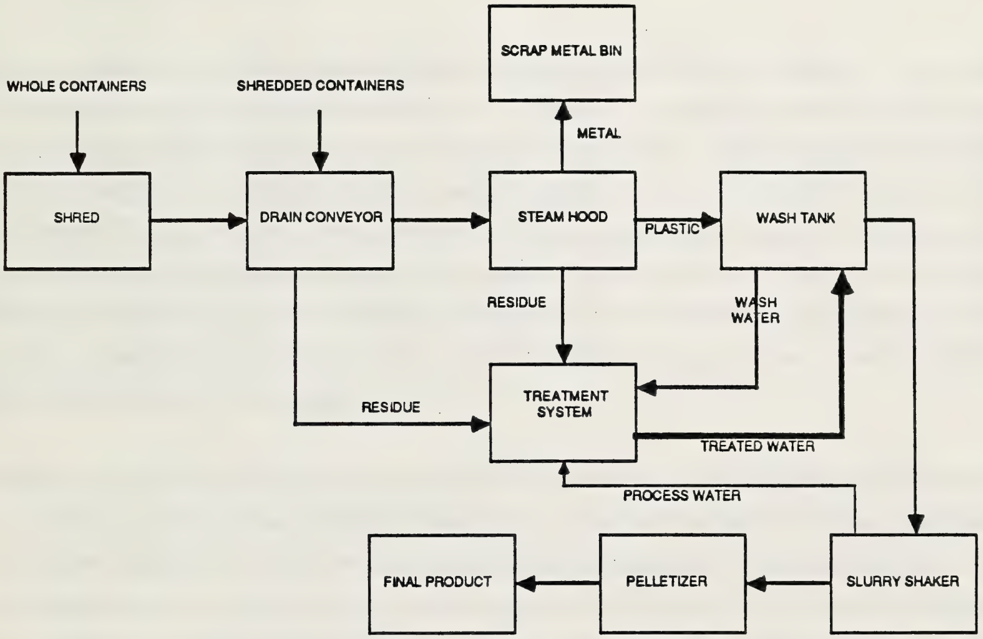


Figure No. 5

Block Flow Diagram
Agrochemical Container Recycling System

1. GAC has been used for the adsorption of organics from contaminated liquids for many years, primarily for applications such as the removal of chlorine, trihalomethane (THM), and THM precursors from potable water.

2. GAC is capable of removing a wide range of organic contaminants in varying concentrations and compositions.
3. Many pesticide process tanks are vented to atmosphere through activated carbon filters.

GAC is capable of removing contaminants at a fairly uniform rate (either in the liquid or the vapour phase) until saturation is achieved, at which point it will allow breakthrough of the contaminants at a relatively rapid rate. Monitoring of the column outfeed is required so that column breakthrough can be observed, and the resin replenished. To ensure that breakthrough of the contaminant to the outfeed does not occur, it is common to route the outfeed through another column in series with the first, and to monitor between the two columns. When the first column has become saturated, the flow is routed to the second column until the first is replenished, at which time it becomes the second in the series.

When the saturation point has been reached, there are three different scenarios that can be used for resin replenishment. Firstly, the resin can be replaced - the spent resin being either landfilled or incinerated, depending on the nature of the contaminant and local regulations. Secondly, the resin can be regenerated - usually achieved through one of two techniques. The first of these is thermal regeneration, accomplished by the addition of sufficient heat energy to overcome the bonding occurring between the resin and the contaminant, and subsequent thermal decomposition of the contaminant itself. The second method is chemical regeneration. A concentrated solution of chemical having a higher affinity for the contaminant than the resin is backflushed through the bed, and either treated by an additional process and subsequently returned back to the process stream (in the case of dye recovery for example), or flushed down the municipal sewer system, depending upon its composition.

In the northeastern part of the United States, thermal regeneration for the mid-volume carbon user is particularly economical, as the carbon companies themselves have trucks which will come to your plant to change your carbon. The spent carbon is regenerated in their own large volume furnace specifically designed for this purpose.

In Alberta, the economies of scale are not as viable as in some other areas in terms of carbon regeneration. Alberta is not as highly industrialized as are the eastern portions of Canada and the USA. In addition, Alberta's industry is not of the type that consumes large volumes of carbon. As a result, other than the city of Regina in its municipal water treatment operation, there are no other usages of carbon in western Canada with consumption large enough to justify in-plant regeneration. New developments in regeneration technology are allowing for the construction of down-sized regeneration ovens to combat these limitations.

C. BIOLOGICAL DEGRADATION

Bacteriological colonies have been made to feed on chlorinated pesticides in the past. This process requires no or low flow conditions for high residence times in a continuous process. These requirements dictate that this technique may be useful for detoxification of the collected residues from a large volume of container's production, but are considered not applicable to an in-process condition, as it is a batch-type process.

D. PHOTODECOMPOSITION BY UV & UV-ASSISTED OZONATION

Recent advances in the field of photodecomposition by UV or UV-assisted Ozonation has proven it to be an economical process for clean-up of organic contaminants from wastewater.

When used in combination with ultraviolet light, ozone becomes a much more effective oxidizing agent. Other oxidizing species are also produced from the water which activates the pollutant molecules, enhancing the reaction rate. As a result, not only are the original polluting species quickly destroyed, but the entire organic content of the water is completely converted back to carbon dioxide, water, and other elementary species. The applicability of the process has been successfully documented for many industrial pollutants such as free and complexed cyanides, pesticides, oxygenated and chlorinated organics, amines, and sulphur and phosphorous containing organic molecules.

A basic industrial system would probably be composed of a multi-staged (2-3) reactor system, run at a flow rate of around 20 gpm minimum. The reason for the reactor multistaging is that in concentrated waste streams, the oxidation rate is mass transfer

limited, but for dilute streams, it is usually reaction rate limited; a multistaged system can have optimum selection of pH, residence time, UV intensity, and temperature for each stage . The staging of the process means that costs are minimized due to the use of smaller tanks, pipes, etc., and the efficiency is optimized by the incorporation of centralized control over the amounts of ozone and UV given at each stage. Excess heat or UV must not be added unnecessarily because they both accelerate the autodecomposition of ozone (especially important in rate of reaction limited systems).

E. FILTRATION

Much work has been done on filtration of pesticide residues. Although routine filtration techniques such as particle filtration, and microfiltration are used, they are most often incorporated into the prefeed treatment for Ultrafiltration (UF) or Reverse Osmosis (RO) beds, and are not in themselves adequate to accomplish most kinds of active ingredient removal.

Osmosis is the diffusion across a membrane of two solutions seeking to obtain equilibrium. If the membrane is semi-permeable, diffusion across the membrane will be limited to specific constituents only. RO is a process to produce high purity water by forcing the passage of water through a semipermeable membrane under sufficient pressure to overcome the natural osmotic pressure, inducing a 'false equilibrium' condition. This results in a concentration of the permeable constituents through the membrane onto one side of the membrane. The water from the side of the membrane holding the concentrated impurities is sent to disposal or further treatment, and the purified water is passed through to further use. Environment Canada has done much work using this technique for clean-up of contaminated lagoons and process streams, and has shown that it can work with pesticide residues to concentrate them into a smaller volume more suited for disposal (it has a lower water content ie.higher BTU content), or further treatment through GAC columns or other methods. One of the main limitations of RO filtration, besides its high capital cost is that because the membrane is semipermeable, various types of membranes produced by various manufacturers are needed to remove various types of contaminants, each also influenced by variables such as pH, turbidity, solvents, and active ingredients. Where a fairly constant process stream, or storage lagoon is to be cleaned up, this limitation can be compensated for - it merely involves identification of the variables, testing of membranes, and installation of a suitable pretreatment system. Problems arise when the composition of the feed

stock to the membranes is not constant; pretreatment must be considered for streams even of known composition, dictated by its composition. Common pretreatment includes pH adjustment, filtration, and microfiltration (to prevent membrane fouling). These requirements suggest that RO is most likely not suitable for processes such as this where the feedstock varies widely - the analytical and pretreatment provisions necessary would not be economical.

UF filtration is very similar to RO, but works over a different particle size range; typically 15 - 2000 Angstroms vs. 1 - 20 Angstroms. This represents particle removal in the molecular weight range vs, the ionic range. As a comparison of the differences between UF and RO, UF will remove oil from oil/water emulsions, and RO will remove NaCl from salt water. UF, because of its similarity to RO has most of the same limitations.

Some of the limitations could be overcome if the residue recovered from a small volume process was stored in a tank for a period of time until a sufficient volume developed to justify this type of treatment. For example, the residue could be collected for a period of one year, mixed until homogeneous, analyzed, pretreated, then treated as a uniform batch. This would produce a concentrated stream of organic contaminants, which could be run through an additional RO column, a granular activated carbon (GAC) column, sent out for incineration, or all of the above, depending upon the economics, and the treatment objectives (it may be possible to send RO discharge through a GAC column, and then directly to drain).

E. TECHNIQUES INVESTIGATED

Due to the technical limitations listed above, as well as for economic considerations and anticipated high capital costs, it was considered feasible to investigate only two of the above treatment technologies in further detail - GAC adsorption, and UV/ Ozone degradation.

SECTION 8

REUSE OF PLASTIC MATERIALS

The high density polyethylene (HDPE) used to package Agrochemicals will absorb some of the contents over a period of time. The quantity of specific contaminants remaining in the plastic which is leachable after recycling will therefore have an influence over the end-use applications the material will be suitable for. To determine suitability, we have initiated a series of analytical and bio-assay tests on the recycled material. The methodologies used for these tests, as well as the results obtained will be investigated by the Canadian Centre for Toxicology. CPIC is advocating an investigation related to their validity and toxicological ramifications. Test results to date indicate possible end-use applications for this material in industrial applications as indicated below.

- blow-molding of horticultural nursery pots.
- sheet extrusion and thermoforming of nursery trays.
- membranes for geotechnical applications.
- agricultural drainage tile.

These products are for non-food use only, and produced by blowmolding or extrusion. Applied Polymer Products Inc., an Edmonton based plastics manufacturing company has indicated that it could use in excess of 2.5 million pounds of recycled HDPE resin per yearfor the production of blow-molded Nursery Pots.

8.1 TEST RESULTS

PRODUCT TESTING

Blow-molded pots were produced from recycled Agrochemical containers, and appear suitable for use in that application, but it is neccesary to carry out analysis to determine the residue content remaining in the plastic at that point. Total Organic Carbon (TOC) testing is a method for detecting the presence of organic molecules in water samples, and was used in an attempt to determine the relative effectiveness of various wash techniques with one another. TOC testing was carried out on samples obtained from

wash trials run on the plastic material. Because the samples were solid, they first had to be leached to pull the TOC into solution. Leaching was carried out under two sets of circumstances, a pH 5.0 controlled pH leaching (EPA mehtod 1310), and a pH 7.0 uncontrolled leach. Details of test procedures are listed in appendix A. Test results obtained were inconclusive however, as the degree of variation in the results was unacceptable. See Figure No. 5 for further details.

BIO-ASSAY TESTING

Bio-assay testing was carried out to study the effects upon germination of Agrochemical contaminated plastics mixed into the growth media of plants. Test procedures used are listed in appendix A. Two types of plants were used - monocots (oats and barley) and dicots (beans and lentils), representative of grassy and broadleaf plants respectively. The plants were observed for a period of 15 days of growth.

After this time it was observed that the residues present in the plastic were sufficient enough to cause a decrease in plant growth in both the dicots, and the monocots. It should be noted that the amounts of plastic incorporated into the soil of the plants presented exposure to the roots of orders of magnitude greater than that which would be experienced under normal growth conditions. These tests cannot therefore be assumed to prove that there will or will not be any effects upon growth of plants grown in containers produced from recycled agrochemical containers at this early stage of testing. This testing was conceived originally only as means of establishing the relative "ladder positioning" of the various wash techniques with each other.

COMMENTS

This initial evaluation study indicates that further testing is necessary to obtain satisfactory results. It is felt that the incorporation of a steam stripping step into the process will increase the effectiveness of the washing operation tremendously, but this must be born out by further research. As well as this, testing should be carried out on further treatment alternatives, especially the oxyphotolysis.

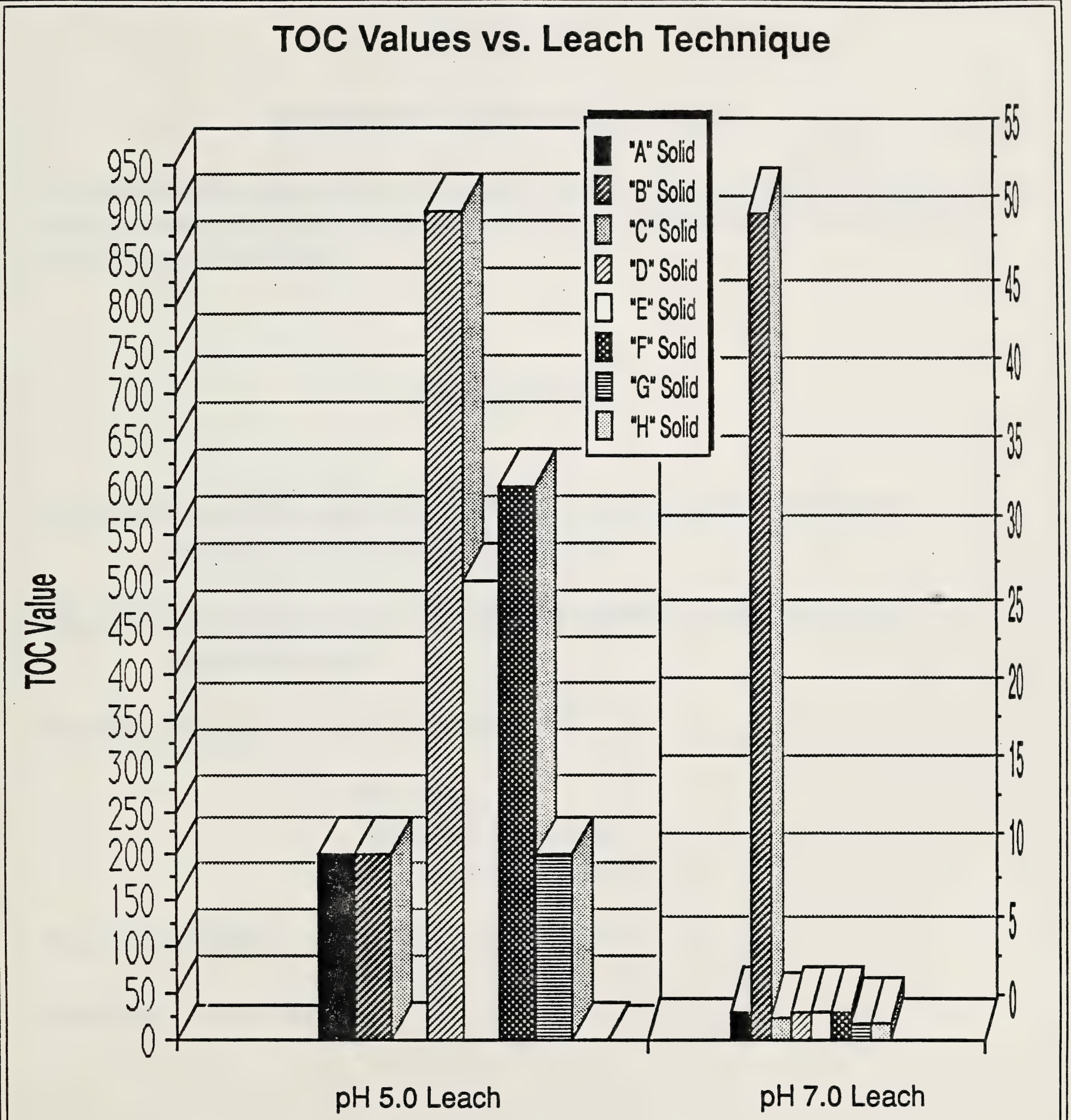


Figure No. 5

A comparison of relative TOC values for two tests on identical samples leached by two different methods. The pH 5.0 leach used an organic acid to control pH, making the recorded TOC values higher.

SECTION 9

ECONOMIC CONSIDERATIONS

The following addendum outlines the capital equipment and operating costs required for the two alternate Agrochemical container disposal options considered in this report, incineration and recycling.

ADDENDUM

Schedule 1. Installed equipment investment and operating expense comparison summary for Incineration and Recycling

Schedule 2. Estimated collection costs for field collection to central transfer & shredding station

Schedule 3. Capital equipment investment costs:

- Shredding
- Treatment & Washing
- Extrusion & Pelletizing

Schedule 4. Recycling - Reclamation processing cost

Schedule 5. Notes to above

SCHEDULE 1

INSTALLED EQUIPMENT INVESTMENT AND OPERATING COST COMPARISON SUMMARY FOR INCINERATION AND RECYCLING

Schedule 1 : INSTALLED EQUIPMENT INVESTMENT AND OPERATING COST COMPARISON SUMMARY FOR ALTERNATIVE DISPOSAL METHODS OF INCINERATION AND RECYCLING

	INCINERATION		RECYCLING					
	PLASTIC	METAL	PLASTIC			METAL		
Range of container volume x1000 lbs			750	1,500	2,250	1,060	2,121	3,182
INSTALLED EQUIPMENT COST, $								
1. Shredding (per Transfer station)	250,992	250,992	250,992			250,992		
2. Treatment & Washing	-	-	736,000			736,000		
3. Extrusion & Pelletizing	-	-	326,130			-		
TOTAL PROCESSING COST , $/lb								
1. Shredding	0.27	0.27	0.27	0.16	0.13	0.19	0.12	0.09
2. Treatment & Washing	-	-	0.36	0.22	0.18	0.25	0.15	0.12
3. Extrusion & Pelletizing	-	-	0.32	0.21	0.17	-	-	-
PACKAGING COST, $/Lb	0.15	0.15	0.10	0.10	0.10	0.10	0.10	0.10
TRANSFER CONTAINER COST,$/Lb								
Shredded plastic	0.092	-	0.031	0.031	0.031	-	-	-
Shredded metal	-	0.031	-	-	-	0.008	0.008	0.008
*Residues	0.006	0.0044	0.006	0.006	0.006	0.0044	0.0044	0.0044
* $/Lb solid waste								
**TRANSPORTATION COST , $/LB								
- Plastic	0.071	-	0.067	0.0067	0.0067	-	-	-
- Metal	-	0.036	-	-	-	0.0343	0.0343	0.0343
- Residues	0.004	0.003	0.0037	0.0037	0.0037	0.0026	0.0026	0.0026
COST TO INCINERATE , $/Lb								
Plastic	0.42	-	-	-	-	-	-	-
Metal	-	0.64	-	-	-	-	-	-
*$/Lb solid *Residues	0.036	0.026	0.036	0.036	0.036	0.026	0.026	0.026
COST TO PROCESS , $/LB	1.05	1.16	1.19	0.77	0.66	0.62	0.45	0.39
RECOVERY EFFICIENCY OF PROCESS	-	-	0.85	0.85	0.85	0.85	0.85	0.85
RECOVERED VALUE , $/LB	-	-	0.16	0.16	0.16	0.03	0.03	0.03
NET COST TO PROCESS,$/LB	**1.05**	**1.16**	**1.24**	**0.75**	**0.62**	**0.69**	**0.49**	**0.42**

** estimated transportation cost does not include cost to transfer whole containers from field collection site to central transfer & shredding facility. Refer to schedule 2 for the estimated field collection costs .

SCHEDULE 2

ESTIMATED COLLECTION COSTS FOR FIELD COLLECTION TO CENTRAL TRANSFER & SHREDDING STATION

Schedule 2 : TRANSPORTATION COST ESTIMATE FOR FIELD COLLECTION SITES TO CENTRAL TRANSFER STATION

> Cost of loading & trucking bulk containers from individual sites to each of the three central transfer shredding station : refer to section 6, figure 3 on map of Alberta.

> Basis of calculation :
- truck equipped with bulk trailer can carry about 4,500-5,000 lbs of whole plastic containers and about 10,000- 12,000 Lbs of whole metal containers.
- trucking costs based on :
1/ $1.00/mile total return trip
2/ crew of two men per trip @ $25/hr including overhead

Summary

Service radius from transfer station to site, miles	*Trucking cost $	Labour cost $	Total cost $	Cost per Lb $/Lb
50	100	(1)500	600	0.13
100	200	(2)600	800	0.17
150	300	(3)1000	1300	0.28

* Return trip
(1) based on 2 trips per day
(2) based on 1 trip per day
(3) based on 2 days per trip

SCHEDULE 3

CAPITAL EQUIPMENT COST

> SHREDDING
> TREATMENT & WASHING
> EXTRUSION & PELLETIZING

ECONOMIC EVALUATION-

PROPOSED CAPITAL INVESTMENT FOR INTEGRATED FACILITY ON RECYCLING AND CONVERSION OF PEST./ HERBICIDE CONTAINERS

DATE TO WHICH ESTIMATE APPLIES : 1 st Quarter 1988

(SHREDDING)

CODE	EQUIPMENT	BUDGET COSTS $ CDN	CDN $
J100	HOPPER DUMPER	4,000	
J103, J104	DRAIN CONVEYORS	12,000	
C107	SHREDDER	25,000	
C109	GRANULATOR	55,000	
H126	STEAM STRIPPER	27,000	
X223	METAL BAGGER	15,000	
X117	METAL DIVERTER	8,000	
X112	FUME HOOD	30,000	176,000
INSTALLATION			
-ELECTRICAL		20,000	
-MECHANICAL		10,000	
ENGINEERING & SUPERVISION @ 15%		26,400	
CONTINGENCY @ 8%		18,592	74,992
INSTALLED EQUIPMENT SUBTOTAL			**250,992**
BUILDING & LAND REQUIREMENT@5,000FT2			**150,000**
BUILDING AND YARD IMPROVEMENT			**40,000**
	FIXED CAPITAL COST		**440,992**

(TREATMENT & WASHING)

		CDN $	CDN $
D134	GAC COLUMN	80,000	
D135	GAC PRETREATMENT	75,000	
D136	SYSTEM R/P	26,000	
E127	BOILER	26,000	
E205	HEATER	12,000	
E206	FLUID BED	38,000	
E207	REGEN. OVEN	60,000	
F119	INTENSE MIXER/ TANK	20,000	
F128, F129 F130, F133 F134	HOLDING TANK	30,000	
F210	SILOS	6,500	
G114, G209	TRANSFER BLOWER	12,000	
H125	HYDROCYCLONES	3,000	
H131	BELT FILTER	18,000	
H132	SLURRY SHAKER	12,000	
H200	SPIN DRYER	30,000	
H136	SCREEN WASHER	10,000	
H207	BAG HOUSE	25,000	
L118, 119 120, 121 122, 123 124	CHEMICAL PUMPS	22,000	**505,500**

INSTALLATION		
- MECHANICAL, INCLUDES PIPING	20,000	
-ELECTRICAL	30,000	
-INSTRUMENTATION & CONTROL @ 6%	30,330	
ENGINEERING & SUPERVISION @ 10%	83,325	
CONTINGENCY @ 10%	66,916	**230,571**

INSTALLED EQUIPMENT SUBTOTAL	**736,071**

(PELLETIZING & EXTRUSION)

		CDN $	SUB TOTAL	
X220	EXTRUDER	150,000		
X221	PELLETIZER	48,000		
X222	FLOOR SCALE	12,000		
X223	PELLET TRANSFER	25,000	235,000	
INSTALLATION		9,000		
- MECHANICAL				
-ELECTRICAL		15,000		
INSTRUMENTATION		15,000		
ENGINEERING & SUPERVISION @15%		36,600		
CONTINGENCY @5 %		15,530	91,130	
INSTALLED EQUIPMENT SUBTOTAL			**326,130**	
COMBINED INSTALLED EQUIPMENT COSTS				
-TREATMENT & WASHING			**736,070**	
-EXTRUSION &PELLETIZATION			**326,130**	
TOTAL INSTALLED EQUIPMENT COST, $			**1,062,200**	
LAND AND BUILDING REQUIREMENT				
-TREATMENT & WASHING @10,000 FT2			**300,000**	
-EXTRUSION & PELLETIZING @ 5,000 FT2			**150,000**	
BUILDING & YARD IMPROVEMENT			**25,000**	
START UP COST			**15,000**	**490,000**
COMBINED FIXED CAPITAL COSTS, $			**1,552,200**	

BUILDING AND LAND INVESTMENT BREAKDOWN

	CDN $
BUILDING REQUIREMENT	
-SHREDDING @5000 FT2	150,000
-WASHING & TREATMENT @ 10000 FT2	300,000
-PELLETIZING (EXTRUSION) @ 5000 FT2	150,000
BUILDING & YARD IMPROVEMENT	65,000
START UP COST	15,000
SUB TOTAL	680,000

DEPRECIATION

	SHREDDING	TREATMENT	PELLETIZING
- BUILDING & YARD @ 3% , $/YEAR	4,500	9,000	4,500
- CAPITALIZED PROCESS EQUIPMENT, $/YEAR 10 YEARS , NO SALVAGE VALUE	22,459	65,275	28,753
TOTAL DEPRECIATION , $/YEAR	26,959	74,275	33,253

PROCESS ECONOMICS ON SHREDDING OF PEST./HERBICIDE CONTAINERS....

BASIS: 450 LBS/HR
1 SHIFT @ 1667 HRS/YR
2 SHIFTS @ 3333 HRS/YR
3 SHIFTS @ 5000 HRS/YR

(SHREDDING OPERATION)

CAPACITY, LBS/YEAR	750,000 1 SHIFT	1,500,000 2 SHIFTS	2,250,000 3 SHIFTS
(DIRECT PRODUCTION COSTS.)			
OPERATING LABOUR	24,000	48,000	80,000
SUPERVISORY	12,000	12,000	12,000
MAINTEANCE	24,000	24,000	24,000
EMPLOYEES' BENEFITS	12,000	16,800	23,200
UTILITIES			
-WATER & ELECTRICITY	4,200	8,500	12,000
MAINTENANCE & REPAIRS	6,000	7,800	10,000
OPERATING SUPPLIES	1,200	1,600	2,000
LABORATORY CHARGES	2,000	2,000	2,000
(FIXED CHARGES.)			
DEPRECIATION			
-PROCESS EQUIPMENT	24,316	24,316	24,316
-YARD & BUILDING	4,500	4,500	4,500
BUSINESS TAX ALLOCATION	4,000	4,000	4,000
INSURANCE ALLOCATION	3,495	3,495	3,495
***TOTAL COST, $/YEAR**	**121,711**	**157,011**	**201,511**
UNIT COST, $/LB	**0.16**	**0.10**	**0.09**

* COST DOES NOT INCLUDE:
- PACKAGING AND TRANSPORT OF CONTAINERS
- PACKAGING, TRANSPORT AND DISPOSAL COST OF CHEMICAL RESIDUES

SCHEDULE 4

RECYCLING – RECLAMATION PROCESSING COST

- › SHREDDING
- › TREATMENT & WASHING
- › EXTRUSION & PELLETIZING

PROCESS ECONOMICS- TREATMENT & WASHING PROCESS

BASIS: 450 LBS/HR
1 SHIFT @ 1667 HRS/YR - 750,000 LBS/YEAR
2 SHIFTS @ 3333 HRS/YR - 1,500,000 LBS/YEAR
3 SHIFTS @ 5000 HRS/YR - 2,250,000 LBS/YEAR

(TREATMENT & WASHING)

CAPACITY, LBS/YEAR	750,000 1 SHIFT	1,500,000 2 SHIFTS	2,250,000 3 SHIFTS
(DIRECT PRODUCTION COSTS.)			
RAW MATERIAL COST	-	-	-
CHEMICAL COST	5,000	7,000	12,000
DISPOSAL COST	1,000	1,500	2,500
OPERATING LABOUR-	24,000	48,000	80,000
SUPERVISORY	12,000	12,000	12,000
MAINTENANCE	24,000	24,000	24,000
EMPLOYEES' BENEFITS	12,000	16,800	23,200
UTILITIES			
-WATER & ELECTRICITY	11,225	22,400	33,600
MAINTENANCE & REPAIRS	5,000	7,500	13,000
OPERATING SUPPLIES	1,200	1,500	2,000
LABORATORY CHARGES	5,000	7,500	10,000
(FIXED CHARGES.)			
DEPRECIATION			
-PROCESS EQUIPMENT	65,257	65,275	65,275
-YARD & BUILDING	9,000	9,000	9,000
BUSINESS TAX ALLOCATION	5,000	5,000	5,000
INSURANCE ALLOCATION	4,270	4,270	4,270
TOTAL COST, $/YEAR	**183,952**	**231,745**	**295,845**
UNIT COST, $/LB	**0.25**	**0.15**	**0.13**

PROCESS ECONOMICS ON EXTRUSION & PELLETIZING OF RECYCLED PESTICIDE CONTAINERS......

BASIS: 450 LBS/HR
1 SHIFT @ 1667 HRS/YR
2 SHIFTS @ 3333 HRS/YR
3 SHIFTS @ 5000 HRS/YR

(EXTRUSION & PELLETIZING)

CAPACITY, LBS/YEAR	**750,000** 1 SHIFT	**1,500,000** 2 SHIFTS	**2,250,000** 3 SHIFTS
(DIRECT PRODUCTION COSTS.)			
RAW MATERIAL COST	-	-	-
DISPOSAL COST	1000	1500	2800
OPERATING LABOUR-	37,600	75,200	112,600
SUPERVISORY	12,000	12,000	12,000
MAINTENANCE	24,000	24,000	24,000
EMPLOYEES' BENEFITS	14,720	22,240	29,760
UTILITIES			
-WATER & ELECTRICITY	15,700	29,000	42,500
MAINTENANCE & REPAIRS	6,000	7,800	10,000
OPERATING SUPPLIES	1,200	1,600	2,000
LABORATORY CHARGES	5,000	5,000	5,000
(FIXED CHARGES.)			
DEPRECIATION			
-PROCESS EQUIPMENT	28,753	28,753	28,753
-YARD & BUILDING	4,500	4,500	4,500
BUSINESS TAX ALLOCATION	3,000	3,000	3,000
INSURANCE ALLOCATION	2,235	2,235	2,235
TOTAL COST, $/YEAR	**155,708**	**216,828**	**279,348**
UNIT COST, $/LB	**0.21**	**0.14**	**0.12**

TOTAL PRODUCT COST- Shredding process

Process operations

1. Shredding
2. Treatment & Washing
3. Extrusion & Pelletization

(Shredding)

Operating capacity, Lbs/Yr		750,000	1,500,000	2,250,000
		1 Shift	2 Shifts	3 Shifts
Fixed Capital Investment	440,992			
Working Capital		7,450	9,750	12,750
Total Capital Investment	453,742			
Total Manufacturing Cost				
- Direct production costs & Fixed Charges		121,711	157,011	201,511
-Total plant overhead costs*		9,620	11,200	12,850
Total General Expenses *		64,700	69,700	71,333
Bank Operating Line Of Credit		6,123	8,000	10,500
Total product cost, $/YEAR		202,154	245,911	296,194
Unit product cost , $/lb		0.27	0.16	0.13

* Costs allocated to 1/3 of each Process operation

TOTAL PRODUCT COST- Treatment & Washing process

Process operations

1. Shredding
2. Treatment & Washing
3. Extrusion & Pelletization

(Treatment & Washing)

Operating capacity, Lbs/Yr		750,000	1,500,000	2,250,000
		1 Shift	2 Shifts	3 Shifts
Fixed Capital Investment				
- Installed equipment cost	736,071			
- land & building investment	300,000			
-Building & Yard improvement	15,000			
- Start up cost	10,000			
Working Capital		11,875	15,200	19,725
Total Capital Investment	1,080,976			
Total Manufacturing Cost				
- Direct Production Costs & Fixed Charges		183,952	231,745	295,845
- Plant Overhead Costs*		9,620	11,200	12,850
Total General Expenses *		64,700	69,700	71,333
Bank Operating Line Of Credit		9,760	12,500	16,210
Total product cost, $		268,032	325,145	396,238
Unit product cost , $/lb		0.36	0.22	0.18

* Costs allocated to 1/3 of each Process operation

TOTAL PRODUCT COST– Extrusion & Pelletizing

Process operations

1. **Shredding**
2. **Treatment & Washing**
3. **Extrusion & Pelletization**

(Extrusion & Pelletizing)

Operating capacity, Lbs/Yr		**750,000**	**1,500,000**	**2,250,000**
		1 Shift	**2 Shifts**	**3 Shifts**
Fixed Capital Investment				
- Installed equipment cost	**326,130**			
- land & building investment	**150,000**			
-Building & Yard improvement	**10,000**			
- Start up cost	**5,000**			
Working Capital		10,000	14,000	18,875
Total Capital Investment	**510,000**			
Total Manufacturing Cost				
- Direct Production Costs & Fixed Charges		155,708	216,828	279,348
- Plant Overhead Costs*		9,620	11,200	12,850
Total General Expenses *		64,700	69,700	71,333
Bank Operating Line Of Credit		8,220	11,500	15,500
Total product cost, $/YEAR		238,248	309,228	379,031
Unit product cost , $/lb		0.32	0.21	0.17

* Costs allocated to 1/3 of each Process operation

SCHEDULE 5

NOTES TO SCHEDULES

Notes to schedule 1 & 2

PROCESS OPERATING COST :

A) INCINERATION
B) RECYCLING

Assumptions:

1) Chemical residues per container is based on 0.3 % by volume.
2) An average distant of 400 miles (return trip) for transportation cost.
3) Average transportation cost of $ 1.00/mile ; a crew of two men on board at $25/manhour
4) Volume of Agrochemical containers :

> 70 % plastic (most 10 L)
> 30 % metal (most 20 L)

VOLUME OF CONTAINERS PER ANNUM AT THREE DIFFERENT SHIFT LEVELS

Plastic	750,000	1,500,000	2,250,000
Metal	321,400	642,900	964,300

TOTAL AVERAGE WEIGHT OF CONTAINERS AND CHEMICAL RESIDUES

Plastic,Lbs	750,000	1,500,000	2,250,000
Metal ,Lbs	1,060,700	2,121,400	3,182,143

Chemical residues contents , Lbs :

Plastic	46,000	92,180	138,300
Metal	39,500	79,000	118,500
Total,Lbs	85,500	171,180	256,800

NOTES TO SCHEDULE 1

1. COST OF INCINERATION AT SWAN HILLS

Plastic @ $0.42/Lb
Metal @ $0.64/Lb
Residue @ $0.32/Lb

2. AVERAGE MATERIAL HANDLING & PACKAGING COSTS

The intermediate packaging cost is estimated :
    Incineration @ $0.15 per Lb
    Recycling @ $0.10 per Lb

Based on drum cost :
Fiber drum (7-8 ft3 capacity) @ $10.0-$12.0 / drum
    > 130 lbs capacity for shredded plastic = $0.092/lb
    > 400 lbs capacity for shredded metal =$0.03/lb
Plastic drum (7-8 ft3 capacity) @ $20.0-$22.0/drum
    > 400 lbs of residues @ $0.055/lb residue

Bulk bag cost (45-50 ft3 capacity) @ $40/piece
    > 1200-1300 lbs capacity for plastic = $0.03/lb
    > 5000 lbs capacity for shredded metal =$0.008/lb

Incineration

Fiber drum is used for both the shredded plastic and metal
Plastic is used for the drained chemical residues

Recycling

Bulk bag is used for the storage of shredded plastic and metal
Plastic drum is used for the drained chemical residues

Operating cost estimate cont....

3. PACKAGING MATERIAL COST

Incineration at Swan Hills	**Number of containers**		
Shredded plastic	5,770	11,540	17,310
Shredded metal	2,121	4,243	6,364
Residues	214	428	642
Number of drums needed	8,105	16,211	24,316
Container cost	**91,500**	**183,000**	**274,540**

Recycling

	Number of containers		
Shredded plastic (bulk bag)	23,100	46,154	69,230
Shredded metal (bulk bag)	8,159	16,300	24,500
Residues	214	428	642
Number of bulk bags	31,259	62,454	93,730
Number of drums	214	428	642
Container cost	**36,000**	**71,950**	**107,800**

Operating cost estimate cont....

4. TRANSPORTATION

Total distance of 400 miles (return trip) is assumed
>based on 2 days/trip
> crew of two men @ $25/hr

Incineration

	$/Lb	$/Lb plastic	$/Lb metal
Shredded plastic	0.071	0.071	-
Shredded metal	0.036	-	0.036
Residues	0.033	0.0037	0.0026

		$/Lb	$/Lb plastic	$/Lb metal
Recycling	Shredded plastic	0.067	0.067	-
	Shredded metal	0.0343	-	0.0343
	Residues	0.033	0.0037	0.0026

SECTION 10

COST REDUCTION ALTERNATIVES

In order to keep costs to everyone down to a minimum, and to further clean our environment in this highly volume-sensitive recycling process, it is recommended that this operation be combined into a multi-plastic recycling operation. Other plastics possible to recycle through their into processing through a plant set-up to recycle Agrochemical containers are:

- polyethylene oil bottles
- polypropylene battery cases
- polyethylene bleach and detergent bottles.

See figure No. 6 for some of the plastics Applied Polymer Research is presently either recycling, or considering to recycle.

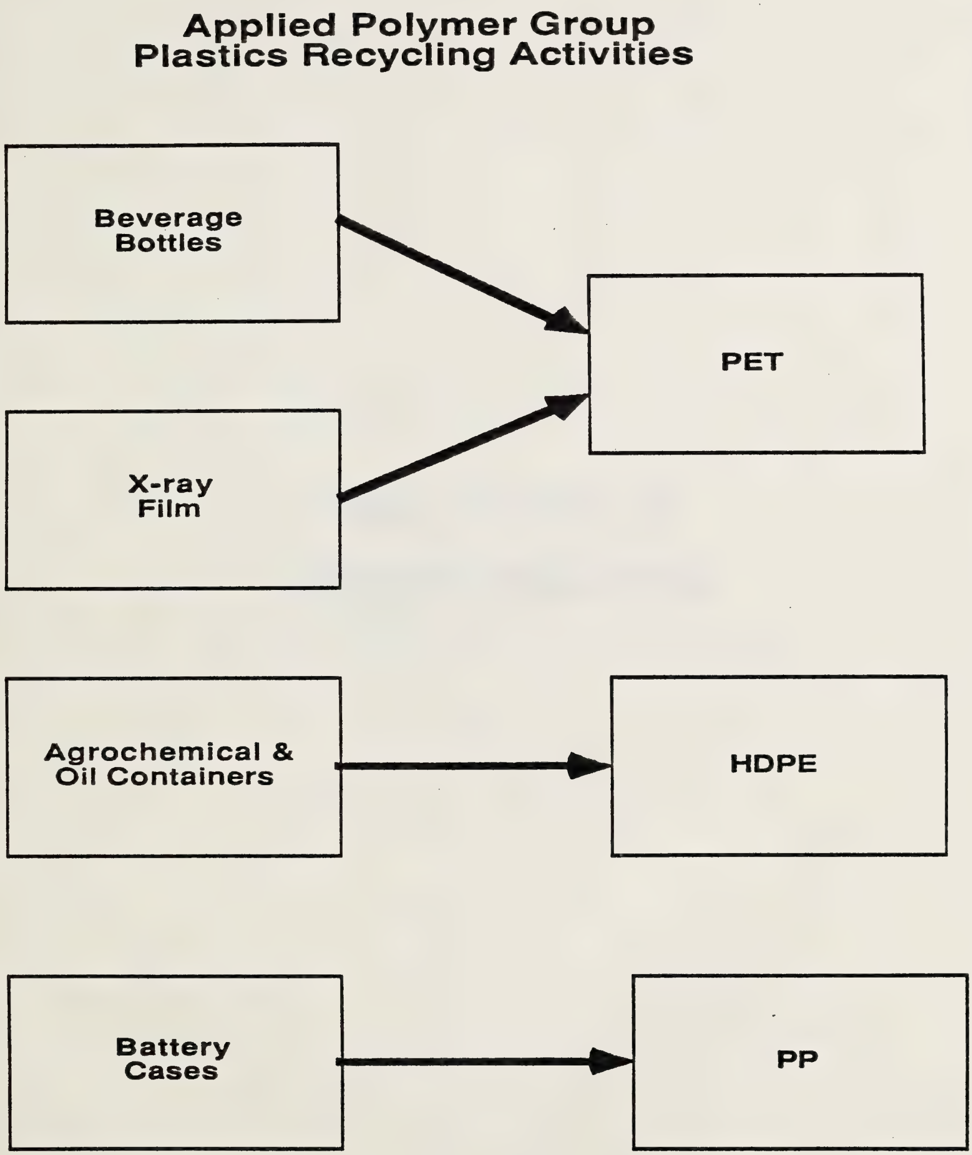

Applied Polymer Group
Plastics Recycling Activities
Beverage Bottles
X-ray Film
PET
Agrochemical & Oil Containers
HDPE
Battery Cases
PP

Figure No. 6

SECTION 11
Appendices

Appendix A

Testing Program
&
Procedures

BIO-ASSAY TEST PROCEDURES

The following is an outline of procedures followed by APR in conducting bio-assay testing for the purposes of this project.

1. Samples of agrochemical containers washed by various means were obtained from previous washing trials, and granulated to fit through a 10 mesh screen.
2. The granulated plastic was mixed 25% by weight into a standard commercial potting soil mix.
3. Into each pot was placed 60 g of soil/plastic mixture, and three seeds. Plants grown were beans, lentils, oats, and barley. For each type of plant, there were 36 pots: four pots each of plastic/soil mix from five different washing methods, a blow-molded pot produced from recycled pesticide container, a blow-molded pot from a standard reprocessed HDPE pot, and plain soil.
4. The pots were then watered with 20 mL of water each, and placed under fluorescent grow-lights which were left on 24 hrs./day.
5. The plants were watered with 20 mL of water daily for a two-week period, and progress of their growth noted.

ANALYTICAL TEST PROCEDURES

The analytical testing conducted for APR was carried out by Enviro-test Laboratories, Edmonton. Analysis were conducted for TOC on six solid samples, using two different leaching techniques, and directly on the liquid pesticide residue sample. A COD was also run on the residue only, as a check on theoretical calculations required for consideration of treatment options. The solid samples were obtained from various washing experiments, and the liquid pesticide residue was obtained from Saskatchewan's 1987 container collection program. Attached is the procedure used for leaching of the solid samples.

pH 5.0 CONTRLLED pH LEACH TEST

WASTE EXTRACTION PROCEDURE

(1) Sampling

Obtain a representative sample of the waste to be tested. The minimum size of this sample should be 100 grams.

(2) Equipment

2.1 A filter holder, 142 mm dia., capable of sustaining a pressure of 5 kg/cm2, applied to the solution to be filtered (Nuclepore Stk. No. 425900 or equivalent).

2.2 142 mm dia. teflon or membrane filters, 0.45 um dia. pore size (Nuclepore Cat. #2100-0016 or equivalent).

2.3. 124 mm dia. glass fibre filters (Nuclepore Type P300. Stk. No. 210708 or equivalent).

2.4 100 mm dia. vacuum filtration unit.

2.5 Pre-purified nitrogen gas under pressure.

2.6 pH meter, calibrated according to standard procedures.

2.7 Teflon bottles, wide mouth 500 ml capacity, with teflon caps (Nalge Cat. #2100-0066 or equivalent).

2.8 Agate or porcelain spheres, 1 cm dia.

(3) Chemicals

3.1 0.5 N Acetic Acid

(4) Separation Procedure

If the sample consists of a solid and liquid phase, separate the sample into its component liquid and solid phases.

4.1 Following the manufacturer's direction, assemble the filter unit with a filter bed consisting of a 0.45 um pore size Teflon membrane filter. For difficult or slow to filter mixtures, a pre-filter bed consisting of the following pre-filters of increasing pore size (0.65 um membrane, fine glass fibre pre-filter, and coarse glass fibre pre-filter) may be used.

4.2 Pour the sample carefully into the filtration unit, without undue aeration.

4.3 Pressurize the reservoir very slowly with nitrogen gas using the valve on the filter holder until liquid begins to flow from the filtrate outlet, at which point lower the pressure on the filter immediately to 0.5 to 1 kg/sq.cm. Continue filtration until liquid flow ceases.

4.4 Increase the pressure step-wise in 0.5 kg/sq.cm increments to 5 kg/sq.cm and continue filtration until the liquid flow ceases or the pressurizing gas begins to exit from the filtrate outlet.

4.5 Depressurize the filter unit slowly, remove and weigh the solid material and then trnasfer it to the extraction apparatus. If the weight is less than 0.5% of the sample, discard the solid portion. Do not allow the material retained in the filter pad to dry prior to the extraction step.

4.6 Measure the volume of the liquid phase. The liquid phase is stored under nitrogen conditions at 4oC for subsequent use in Step (5.10) of the extraction procedure.

Note: For mixtures containing non-absorptive solids where separation can be offered without imposing a 5 kg/sq cm differential pressure, a vacuum filter, employing a 0.45 um dia. pore size filter, may be used.

(5) Extraction Procedure

5.1 If the original sample consists of solid material, or using the solid material from step (4.5) prepare it for extraction by crushing, cutting or grinding, using the appropriate materials (see 'Precautions" following), to pass through a 5 mm mesh opening sieve.

5.2 Note: A rubber type of waste may be prepared for extraction by shredding after freezing with liquid nitrogen.

5.3 The solid material is quartered and riffled to obtain a sample representative of the waste. If it is required that the structural integrity of the material be determined, it should be subjected to the "Structural Integrity Procedure" as described below. Do not allow the solid material to dry prior to weighing for the extraction step.

5.4 Determine the moisture content of the de-watered sample, by drying suitable aliquot to constant weight at 105oC in an oven.

5.5. Place enough of the de-watered undried material in a 500 ml wide mouth teflon bottle to provide 25 g of the dry material.

5.6 Add 400 ml of de-oxygenated distilled water.

5.7 Measure the pH of the solution, in the teflon bottle, using a calibrated pH meter.

Procedure for Co-disposal Samples

5.7.1 If the pH is less than 5.0 0.2, add 100 ml of deoxygenated water and proceed to step (5.7.3).

5.7.2 If the pH is greater than 5 : 0.2 add a sufficient volume 0.5 N acetic acid, to bring the pH to 5 : 0.2.

Note: No more than 100 ml of the acetic acid may be added during the procedure.

5.7.3 Agitate the mixture for 24 hours and maintain the temperature at 20o to 25o C during this time period. It is recommended that the operator monitor and adjust the pH during the course of the extraction either manually or using the pH controller. If a pH controller is not available, the following procedure should be employed.

(i) Adjust the pH of the solution at 15, 30 and 60 minute intervals moving to the next longer interval if the pH does not have to be adjusted more than 0.5 pH units.

(ii) Continue the adjustment procedure for at least six hours.

(iii) If at the end of the 24 hour extraction period, the pH of the solution is not below 5.2 and the maximum amount of acid (100 mL) has not been added, adjust the pH to 5.0 ± 2 and continue extraction for an additional four hours, during which time the pH should be adjusted at one hour intervals.

5.7.4 At the end of the 24 hour extraction period, add de-oxygenated water as determined by the following equation: V = 100 - A where V = millilitres de-oxygenated water to be added: A = Millilitres of 0.5% acetic acid added during the procedure.

Note: For the purposes of this test, an acceptable extractor is one which will impart sufficient agitation to the mixture to not only prevent stratification of the sample and extraction fluid but also ensure that all sample surfaces are continually brought into contact with well-mixed extraction fluid.

pH 7.0 LEACH TEST

The leach test for the pH 7.0 water sample was conducted using the same procedure, however pH 7.0 water was used for the test, and the pH was not adjusted by the operator during the test period.

with deionized water. Standardize nst 0.1N NaOH.

rocedure

Recovery factor: To determine the re-ry factor, f, for a given apparatus, di- an appropriate volume of acetic acid k solution to 250 mL in a volumetric : to approximate the expected sample centration and distill as for a sample. ulate the recovery factor

$$f = \frac{a}{b}$$

re:

a = volatile acid concentration recovered in distillate, mg/L, and
b = volatile acid concentration in standard solution used, mg/L.

Sample analysis: Centrifuge 200 mL ple for 5 min. Pour off and combine rnatant liquors. Place 100 mL super-nt liquor in a 500-mL distillation flask. l 100 mL distilled water, four to five clay chips or similar material to prevent bumping, and 5 mL H_2SO_4. Mix so that acid does not remain on bottom of flask. Connect flask to a condenser and adapter tube and distill at the rate of about 5 mL/min. Discard the first 15 mL and collect exactly 150 mL distillate in a 250-mL graduated cylinder. Titrate with 0.1N NaOH, using phenolphthalein indicator, a pH meter, or an automatic titrator. The end points of these three methods are, respectively, the first pink coloration that persists on standing a short time, pH 8.3, and the inflection point of the titration curve (see Section 402). Titration at 95°C produces a stable end point.

5. Calculation

$$\text{mg volatile acids as acetic acid/L} = \frac{\text{mL NaOH} \times N \times 60\,000}{\text{mL sample} \times f}$$

where:

N = normality of NaOH, and
f = recovery factor.

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505 ORGANIC CARBON (TOTAL)[*]

The organic carbon in water and wastewater is composed of a variety of organic compounds in various oxidation states. Some of these carbon compounds can be oxidized further by biological or chemical processes, and the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) may be used to characterize these fractions. The presence of organic carbon that does not respond to either the BOD or COD test makes them unsuitable for the measurement of total organic carbon. Total organic carbon (TOC) is a more convenient and direct expression of total organic content than either BOD or COD, but does not provide the same kind of information. If a repeatable empirical relationship is established between TOC and BOD or COD, then TOC can be used to estimate the accompanying BOD or COD. This relationship must be established independently for each set of matrix conditions, such as various points in a treatment process. Unlike BOD or COD, TOC is independent of the oxidation state of the organic matter and does not measure other organically bound elements, such as nitrogen and hydrogen, and inorganics that can contribute to the oxygen demand measured by BOD and COD. TOC measurement does not replace BOD and COD testing.

To determine the quantity of organically bound carbon, the organic molecules must be broken down to single carbon units and converted to a single molecular form that can be measured quantitatively. TOC methods utilize heat and oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants to convert organic carbon to carbon dioxide (CO_2). The CO_2 may be measured directly by a nondispersive infrared analyzer, it may be reduced to methane and measured with a flame ionization detector, or CO_2 may be titrated chemically.

The methods and instruments used in measuring TOC analyze fractions of total carbon (TC) and measure TOC by two or more determinations. These fractions of total carbon are defined as: inorganic carbon (IC)—the carbonate, bicarbonate, and dissolved CO_2; total organic carbon (TOC)—all carbon atoms covalently bonded in organic molecules; dissolved organic carbon (DOC)—the fraction of TOC that passes through a 0.45-μm-pore-diam filter; nondissolved organic carbon (NDOC)—also referred to as particulate organic carbon, the fraction of TOC retained by a 0.45-μm filter; purgeable organic carbon (POC)—also referred to as volatile organic carbon, the fraction of TOC removed from an aqueous solution by gas stripping under specified conditions; and nonpurgeable organic carbon (NPOC)—the fraction of TOC not removed by gas stripping.

In most water samples, the IC fraction is many times greater than the TOC fraction. Eliminating or compensating for IC interferences requires multiple determinations to measure true TOC. IC interference can be eliminated by acidifying samples to pH 2 or less to convert IC species to CO_2. Subsequently, purging the sample with a purified gas removes the CO_2 by volatilization. Sample purging also removes POC so that the organic carbon measurement made after eliminating IC interferences is actually a NPOC determination; determine POC to measure true TOC. In many surface and ground waters the POC contribution to TOC is negligible. Therefore, in practice, the NPOC determination is substituted for TOC.

The purgeable fraction of TOC is a function of the specific conditions and equipment employed. Sample temperature and

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[*] Approved by Standard Methods Committee, 1985.

salinity, gas-flow rate, type of gas diffuser, purging-vessel dimensions, volume purged, and purging time affect the division of TOC into purgeable and nonpurgeable fractions. When separately measuring POC and NPOC on the same sample, use identical conditions for purging during the POC measurement as in purging to prepare the NPOC portion for analysis. Consider the conditions of purging when comparing POC or NPOC data from different laboratories or different instruments.

Alternatively, IC interference may be compensated for by separately measuring total carbon (TC) and inorganic carbon. The difference between TC and IC is TOC.

Selection of method: The combustion-infrared method (A) is suitable for samples with TOC ≥1 mg/L. For lower concentrations, use the persulfate-ultraviolet oxidation method (B) or the wet-oxidation method (C). See 505A.1, 505B.1, and 505C.1.

probably most applicable

505 A. Combustion-Infrared Method

1. General Discussion

The combustion-infrared method has been used for a wide variety of samples, but its accuracy is dependent on particle size reduction because it uses small-orifice syringes.

a. Principle: The sample is homogenized and diluted as necessary and a microportion is injected into a heated reaction chamber packed with an oxidative catalyst such as cobalt oxide. The water is vaporized and the organic carbon is oxidized to CO_2 and H_2O. The CO_2 from oxidation of organic and inorganic carbon is transported in the carrier-gas streams and is measured by means of a nondispersive infrared analyzer.

Because total carbon is measured, IC must be measured separately and TOC obtained by difference.

Measure IC by injecting the sample into a separate reaction chamber packed with phosphoric acid-coated quartz beads. Under the acidic conditions, all IC is converted to CO_2, which is measured. Under these conditions organic carbon is not oxidized and only IC is measured.

Alternatively, convert inorganic carbonates to CO_2 with acid and remove the CO_2 by purging before sample injection. The sample contains only the NPOC fraction of total carbon; a POC determination also is necessary to measure true TOC.

b. Interference: Removal of carbonate and bicarbonate by acidification and purging with purified gas results in the loss of volatile organic substances. The volatiles also can be lost during sample blending, particularly if the temperature is allowed to rise. Another important loss can occur if large carbon-containing particles fail to enter the needle used for injection. Filtration, although necessary to eliminate particulate organic matter when only DOC is to be determined, can result in loss or gain of DOC, depending on the physical properties of the carbon-containing compounds and the adsorption of carbonaceous material on the filter, or its desorption from it. Check filters for their contribution to DOC by analyzing a filtered blank. Note that any contact with organic material may contaminate a sample. Avoid contaminated glassware, plastic containers, and rubber

tubing. Analyze treatment, system, and reagent blanks.

c. Minimum detectable concentration: 1 mg carbon/L. This can be achieved with most combustion-infrared analyzers although instrument performance varies. The minimum detectable concentration may be reduced by concentrating the sample, or by increasing the portion taken for analysis.

d. Sampling and storage: Collect and store samples in amber glass bottles with TFE-lined cap. Before use, wash bottles with acid, seal with aluminum foil, and bake at 400°C for at least 1 h. Wash TFE septa with detergent, rinse repeatedly with organic-free water, wrap in aluminum foil, and bake at 100°C for 1 h. Preferably use thick silicone rubber-backed TFE septa with open ring caps to produce a positive seal. Because the detection limit is relatively high, less rigorous cleaning may be acceptable; use bottle blanks with each set of samples. Use a Kemmerer or similar type sampler for collecting samples from a depth exceeding 2 m. Preserve samples that cannot be examined promptly by holding at 4°C with minimal exposure to light and atmosphere. Acidification with phosphoric or sulfuric acid to a pH ≤2 may be used only if inorganic carbon subsequently is purged. Under any conditions, minimize storage time.

2. Apparatus

*a. Total organic carbon analyzer.**

b. Syringes: 0 to 50-µL, 0 to 200-µL, 0 to 500-µL, and 0 to 1-mL capacity.†

c. Sample blender or homogenizer.

d. Magnetic stirrer and TFE-coated stirring bars.

e. Filtering apparatus and 0.45-µm-pore-diam filters.

3. Reagents

a. Reagent water: Prepare blanks and standard solutions from carbon-free water; preferably use carbon-filtered, redistilled water.

b. Phosphoric acid, H_3PO_4, conc. Alternatively use sulfuric acid, H_2SO_4, but not hydrochloric acid.

c. Organic carbon stock solution: Dissolve 2.1254 g anhydrous potassium biphthalate, $C_8H_5KO_4$, in carbon-free water and dilute to 1000 mL; 1.00 mL = 1.00 mg carbon. Alternatively, use any other organic-carbon-containing compound of adequate purity, stability, and water solubility. Preserve by acidifying with H_3PO_4 or H_2SO_4 to pH ≤2.

d. Inorganic carbon stock solution: Dissolve 4.4122 g anhydrous sodium carbonate, Na_2CO_3, in water, add 3.497 anhydrous sodium bicarbonate, NaHCO and dilute to 1000 mL; 1.00 mL = 1.0 mg carbon. Alternatively, use any othe inorganic carbonate compound of adequat purity, stability, and water solubility. Kee tightly stoppered. Do not acidify.

e. Carrier gas: Purified oxygen or ai CO_2-free and containing less than 1 pp hydrocarbon (as methane).

f. Purging gas: Any gas free of CO_2 an hydrocarbons.

4. Procedure

a. Instrument operation: Follow manu facturer's instructions for analyzer assem bly, testing, calibration, and operatio Adjust to optimum combustion tempera ture (900°C) before using instrument; mor itor temperature to insure stability.

b. Sample treatment: If a sample contain gross solids or insoluble matter, homog nize until satisfactory replication is ot tained. Analyze a homogenizing blan consisting of reagent water carried throug the homogenizing treatment.

If inorganic carbon must be removed b fore analysis, transfer a representative po

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*Beckman Instruments Model No. 915B or equivalent.
†Hamilton No. 705 N or 750 N, CR-700-20 or CR-700-200 with needle point style No. 3, or equivalent. Spring-loaded syringe may improve reproducibility.

tion of 10 to 15 mL to a 30-mL beaker, add conc H_3PO_4 to reduce pH to 2 or less, and purge with gas for 10 min. Do not use plastic tubing. Inorganic carbon also may be removed by stirring the acidified sample in a beaker while directing a stream of purified gas into the beaker. Because volatile organic carbon will be lost during purging of the acidified solution, report organic carbon as total nonpurgeable organic carbon.

If the available instrument provides for a separate determination of inorganic carbon (carbonate, bicarbonate, free CO_2) and total carbon, omit decarbonation and proceed according to the manufacturer's directions to determine TOC by difference between TC and IC.

If dissolved organic carbon is to be determined, filter sample through 0.45-µm-pore-diam filter with vacuum; analyze a filtering blank.

c. Sample injection: Withdraw a portion of prepared sample using a syringe fitted with a blunt-tipped needle. Select sample volume according to manufacturer's direction. Stir samples containing particulates with a magnetic stirrer. Select needle size consistent with sample particulate size. Inject samples and standards into analyzer according to manufacturer's directions and record response. Repeat injection until consecutive peaks are obtained that are reproducible to within ±10%.

d. Preparation of standard curve: Prepare standard organic and inorganic carbon series by diluting stock solutions to cover the expected range in samples. Inject and record peak height of these standards and a dilution water blank. Plot carbon concentration in milligrams per liter against corrected peak height in millimeters on rectangular coordinate paper. This is un[illegible]ssary for instruments provided with a [illegible]al readout of concentration. If desirable, prepare a standard curve having concentrations of 1 to 10 mg/L by making appropriate dilutions of the standards.

With most TOC analyzers, it is not possible to determine separate blanks for reagent water, reagents, and the entire system. In addition, some TOC analyzers produce a variable and erratic blank that cannot be corrected reliably. In many laboratories, reagent water is the major contributor to the blank value. Correcting only the peak heights of standards (which contain reagent water + reagents + system blank) creates a positive error, while also correcting samples (which contain only reagents and system blank contributions) for the reagent water blank creates a negative error. Minimize errors by using reagent water and reagents low in carbon.

Inject samples and procedural blanks (consisting of reagent water taken through any pre-analysis steps—values are typically higher than those for reagent water) and determine sample organic carbon concentrations by comparing corrected peak heights to the calibration curve.

5. Calculations

a. When reagent water is a major portion of the total blank:

1) Calculate corrected peak height of standards by subtracting the reagent-water blank peak height from the standard peak heights.

2) Prepare a standard curve of corrected peak height vs. TOC concentration.

3) Subtract the procedural blank from each sample peak height and compare to the standard curve to determine carbon content.

NOTE: There will be a positive error if the TOC of the reagent water is significant in comparison to the TOC of the sample. Make a special effort to obtain carbon-free reagent water.

4) Apply the appropriate dilution factor when necessary.

5) Subtract the inorganic carbon from the total carbon when TOC is determined by difference.

b. When reagent water is a minor portion of the total blank:

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1) Calculate corrected peak height of standards and samples by subtracting the reagent-water blank peak height from the standard and sample peak heights.

2) Prepare a standard curve of corrected peak height vs. TOC concentration.

3) Subtract the procedural blank from each sample peak height and compare to the standard curve to determine the carbon content. Values will have a negative error equal to the blank contribution from the reagent water.

4) Apply the appropriate dilution factor when necessary.

5) Subtract the inorganic carbon from the total carbon when TOC is determined by difference.

NOTE: If the TOC analyzer design pe mits isolation of each of the contributio to the total blank, apply appropriate blai corrections to peak heights of standar (reagent blank, water blank, system blan and sample (reagent blank and syste blank).

6. Precision

The difficulty of sampling particula matter on unfiltered samples limits the pı cision of the method to approximately 5 10%. On clear samples or on those th have been filtered before analysis, precisi approaches 1 to 2% or ± 1 to 2 mg ca bon/L, whichever is greater.

505 B. Persulfate-Ultraviolet Oxidation Method

1. General Discussion

Many instruments utilizing persulfate oxidation of organic carbon are available. They depend either on heat or ultraviolet irradiation activation of the reagents. The persulfate-ultraviolet oxidation method is a rapid, precise method for the measurement of trace levels of organic carbon in water and is of particular interest to the electronic, pharmaceutical, and steam-power-generation industries where even trace concentrations of organic compounds may degrade ion-exchange capacity, serve as a nutrient source for biological growth, or be detrimental to the process for which the water is being utilized.

a. Principle: Organic carbon is oxidized to carbon dioxide, CO_2, by persulfate in the presence of ultraviolet light. The CO_2 produced may be measured directly by a nondispersive infrared analyzer, be reduced to methane and measured by a flame ionization detector, or be chemically titrated.

Instruments are available that utilize ultraviolet lamp submerged in a contin ously gas-purged reactor that is filled wi a constant-feed persulfate solution. T samples are introduced serially into the r actor by an autosampler or they are i jected manually. The CO_2 produced sparged continuously from the solution a is carried in the gas stream to an infrar analyzer that is specifically tuned to t absorptive wavelength of CO_2. The instr ment's microprocessor calculates the ar of the peaks produced by the analyz compares them to the peak area of the c ibration standard stored in its memory, a prints out a calibrated organic carbon val in milligrams per liter.

b. Interferences: See Section 505A.1. E cessive acidification of sample, produci a reduction in pH of the persulfate soluti to 1 or less, can result in sluggish and i complete oxidation of organic carbon.

The intensity of the ultraviolet lig reaching the sample matrix may be reduc

by highly turbid samples or with aging of the ultraviolet source, resulting in sluggish or incomplete oxidation. Large organic particles or very large or complex organic molecules such as tannins, lignins, and humic acid may be oxidized slowly because persulfate oxidation is rate-limited. Because the efficiency of conversion of organic carbon to CO_2 may be affected by many factors, check efficiency of oxidation with selected model compounds representative of the sample matrix.

Persulfate oxidation of organic molecules is slowed in samples containing significant concentrations of chloride by the preferential oxidation of chloride; at a concentration of 0.1%, chloride oxidation of organic matter may be inhibited completely. To remove this interference add mercuric nitrate to the persulfate solution.

With any organic carbon measurement, contamination during sample handling and treatment is a likely source of interference. This is especially true of trace analysis. Take extreme care in sampling, handling, and analysis of samples below 1 mg TOC/L.

c. Minimum detectable concentration: Concentration of 0.05 mg organic carbon/L can be measured if scrupulous attention is given to minimizing sample contamination and method background. Use the combustion-infrared method (A) for high concentrations of TOC.

d. Sampling and storage: See Section 505A.1*d*.

2. Apparatus

*a. Total organic carbon analyzer.**

b. Syringes: 0 to 50-μL, 0 to 250-μL, and 0 to 1-mL capacity, fitted with a blunt-tipped needle.

3. Reagents

See Section 505A.3.

4. Procedure

a. Instrument operation: Follow manufacturer's instructions for assembly, testing, calibration, and operation.

b. Sample preparation: If a sample contains gross particulates or insoluble matter, homogenize until a representative portion can be withdrawn through the syringe needle or autosampler tubing.

If dissolved organic carbon is to be determined, filter sample and a reagent water blank through 0.45-μm glass fiber filter with vacuum. Pretreat filter by submerging overnight in a 1:1 solution of HNO_3 and reagent water and collect in an acid-washed, baked flask. Use a clean filter and flask for each sample.

To determine NPOC, transfer 15 to 30 mL sample to a flask or test tube and acidify to a pH of 2. Purge according to manufacturer's recommendations.

c. Sample injection: See Section 505A.4*c*.

d. Standard curve preparation: Prepare an organic carbon standard series over the range of organic carbon concentrations in the samples. Inject standards and blanks and record analyzer's response. Determine peak area for each standard and blank. Determinations based on peak height may be inadequate because of differences in the rate of oxidation of standards and samples. Correct peak area of standards by subtracting reagent water blank and plot organic carbon concentration in milligrams per liter against corrected peak area. For instruments providing a digital readout of concentration, this is not necessary.

Inject samples, treatment blanks, if applicable, and instrument blank. Subtract appropriate blank's peak area from each sample's peak area and determine organic carbon from the standard curve.

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*Xertex-Dohrmann DC-80 or equivalent.

5. Calculation

See Section 505A.5 but use peak area rather than peak height.

6. Precision and Accuracy

See Table 505:I.

TABLE 505:I. PRECISION AND ACCURACY FOR TOTAL ORGANIC CARBON (TOC) BY PERSULFAT
ULTRAVIOLET OXIDATION

Characteristic of Analysis	Spring Water	Spring Water +0.15 mg/L KHP*	Tap Water	Tap Water +10 mg/L KHP*	Municip Wastewat Effluent
Concentration determined, mg/L:					
Replicate 1	0.402	0.559	2.47	11.70	5.88
Replicate 2	0.336	0.491	2.49	11.53	5.31
Replicate 3	0.340	0.505	2.47	11.70	5.21
Replicate 4	0.341	0.523	2.47	11.64	5.17
Replicate 5	0.355	0.542	2.46	11.55	5.10
Replicate 6	0.366	0.546	2.46	11.68	5.33
Replicate 7	0.361	0.548	2.42	11.55	5.35
Mean (mg/L)	0.35	0.53	2.46	11.53	5.32
Standard deviation:					
mg/L	0.02	0.03	0.02	0.21	0.23
%	6	6	1	2	4
Actual value, mg/L	—	0.50	—	12.46	—
Recovery, %	—	106	—	93	—
Error, %	—	6	—	7	—

*KHP = potassium acid phthalate.

505 C. Wet-Oxidation Method

1. General Discussion

The wet-oxidation method is suitable for the analyses of water, water-suspended sediment mixtures, brines, and wastewaters containing at least 0.1 mg nonpurgeable organic carbon (NPOC)/L. The method is not suitable for the determination of volatile organic constituents.

a. Principle: The sample is acidified, purged to remove inorganic carbon, and oxidized with persulfate in an autoclave a temperatures from 116 to 130°C. The re sultant carbon dioxide (CO_2) is measure by nondispersive infrared spectrometry.

b. Interferences: See Section 505A.1 an B.1.

c. Minimum detectable concentration High concentrations of reducing agent may interfere. Concentration of 0.10 m organic carbon/L can be measured if scru pulous attention is given to minimizin

sample contamination and method background. Use the combustion-infrared method (A) for high concentrations of TOC.

d. Sampling and storage: See Section 505A.1*d*.

2. Apparatus

a. Ampules, precombusted, 10-mL, glass.*

*b. Ampule purging and sealing unit.**

*c. Autoclave.**

*d. Carbon analyzer.**

e. Homogenizer.†

3. Reagents

In addition to the reagents specified in Section 505A.3*a*, *c*, *e*, and *f*, the following reagents are required:

a. Phosphoric acid solution, H_3PO_4, 1.2*N*: Add 83 mL H_3PO_4 (85%) to water and dilute to 1 L with water. Store in a tightly stoppered glass bottle.

b. Potassium persulfate, reagent-grade, granular. Avoid using finely divided forms.

4. Procedure

a. Instrument operation: Follow manufacturer's instructions for assembly, testing calibration, and operation. Add 0.2 g potassium persulfate using a dipper calibrated to deliver 0.2 g and 0.5 mL 1.2*N* H_3PO_4 solution to precombusted ampules.

To analyze for dissolved organic carbon, pass sample and reagent water blank under vacuum through a separate 0.45-µm glass fiber filter that was pretreated by submerging overnight in a 1:1 solution of HNO_3 and reagent water and collect in acid-washed, baked flasks. Use clean filter and flask for each sample.

Homogenize sample to produce a uniform suspension. Rinse homogenizer with reagent water after each use. Pipet water sample (10.0 mL maximum) into an ampule. Adjust smaller volumes to 10 mL with reagent water. Prepare one reagent blank (10 mL reagent water plus acid and oxidant) for every 15 to 20 water samples. Prepare standards covering the range of 0.1 to 40 mg carbon/L by diluting the carbon standard solution. Immediately place filled ampules on purging and sealing unit and purge them at rate of 60 mL/min for 6 min with purified oxygen. Seal samples according to the manufacturer's instructions. Place sealed samples, blanks, and a set of standards in ampule racks in an autoclave and digest 4 h at temperature between 116 and 130°C.

Set sensitivity range of carbon analyzer by adjusting the zero and span controls in accordance with the manufacturer's instructions. Break combusted ampules in the cutter assembly of the carbon analyzer, sweep CO_2 into the infrared cell with nitrogen gas, and record area of each CO_2 peak. CAUTION: *Because combusted ampules are under positive pressure, handle with care to prevent explosion.*

5. Calculations

Prepare an analytical standard curve by plotting peak area of each standard versus concentration (mg/L) of organic carbon standards. The relationship between peak area and carbon concentration is curvilinear. Define operating curves each day samples are analyzed.

Report nonpurgeable organic carbon concentration (NPOC) as follows: 0.1 mg/L to 0.9 mg/L, one significant figure; 1.0 mg/L and above, two significant figures.

6. Precision and Accuracy

Multiple determinations of four different concentrations of aqueous potassium acid

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*Oceanographics International Corp. or equivalent.

†Willems Polytron PT-105T. Brinkman Inst., or equivalent.

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phthalate samples at 2.00, 5.00, 10.0, and 40.0 mg carbon/L resulted in mean values of 2.2, 5.3, 9.9, and 38 mg/L and standard deviations of 0.13, 0.15, 0.11, and 1.4, respectively.

Precision also may be expressed in terms of percent relative standard deviation as follows:

Number of Replicates	Mean *mg/L*	Relative Standard Deviation %
9	2.2	5.9
10	5.3	2.8
10	9.9	1.1
10	38.0	3.7

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506 ORGANIC HALOGEN (TOTAL)*

Adsorption-Pyrolysis-Titrimetric Method (TENTATIVE)

Total organic halogen (TOX) is a surrogate measurement used to estimate the total quantity of halogenated organic material in a water sample. The presence of halogenated organic molecules is indicative of synthetic chemical contamination. Halogenated compounds that contribute to a TOX result include, but are not limited to: the trihalomethanes (THMs); organic solvents such as trichloroethene, tetrachloroethene, and other halogenated alkanes and alkenes; chlorinated and brominated pesticides and herbicides; polychlorinated biphenyls (PCBs); chlorinated aromatics such as hexachlorobenzene and 2,4-dichlorophenol; and high-molecular-weight, partially chlorinated THM precursors. This test measures only the total molar amount of organically bound halogen and does not yield information about the structure or nature of the organic compounds to which the halogens are bound, nor information about the individual halogens present.

TOX measurement is an inexpensive and useful method for screening large numbers of samples before specific (and often more complex) analyses; for extensive field surveying for pollution by certain classes of synthetic organic compounds in natural waters; for mapping the extent of organohalide contamination in groundwater; for monitoring the breakthrough of some synthetic organic compounds in water treatment processes; and for estimating the level of formation of chlorinated organic by-products after disinfection with chlorine. In general, a positive TOX test result indicates the need for identifying and quantifying specific substances. In saline or brackish waters the high inorganic halogen concentrations interfere. The possibility of overestimating TOX concentration because of inorganic halide interference always should be considered when interpreting results.

The TOX method is sensitive to organic chloride, bromide, and iodide, but does not detect fluorinated organics. The microcoulometric detector operates by maintaining a constant silver-ion concentration in a titration cell. An electric potential is applied to a solid silver electrode to produce silver ions in the cell solution. As hydrogen halide from the pyrolysis enters the cell in the carrier gas, it is partitioned into the acetic acid solution where it precipitates as silver halide. This produces a current that is integrated over the period of the pyrolysis. The integrated area under the curve is proportional to the number of moles of halogen recovered. The mass concentration of organic halides is reported as an equivalent concentration of organically bound chloride in micrograms per liter. As a consequence of this conversion from moles of halide to mass concentration in terms of chloride, the accuracy of the method is a function of the particular halides present.

1. General Discussion

a. Principle: The method consists of four processes. First, organic material is concentrated from the aqueous solution by adsorption onto granular activated carbon (GAC). Second, inorganic halides present on the GAC are removed by competitive displacement by nitrate ions. Third, the GAC with adsorbed organic material is introduced into a furnace that pyrolyzes organic carbon to carbon dioxide (CO_2) and the bound halogens to hydrogen halide (HX). Fourth, the HX is transported in a carrier gas stream to a microcoulometric titration cell where the amount of halide is quantified by measuring the current produced by silver-ion precipitation of the halides.

When a sample is purged with inert gas before GAC adsorption, analysis of that sample determines the nonpurgeable organic halogen (NPOX) fraction of TOX.
The purgeable organic halogen concentr
tion (POX) may be calculated by subtrac
ing the NPOX value from the TOX valu
Alternatively, the POX fraction may t
determined directly by purging the samp
with carrier gas and introducing that g
stream and the volatilized organics directl
into the pyrolysis furnace. From the ana
ysis of POX and TOX, NPOX may t
determined by difference.

b. Interferences: Inorganic substanc
such as chloride, chlorite, chlorate, br
mide, and iodide will adsorb on GAC t
an extent dependent on their original co
centration in the aqueous solution and th
volume of sample filtered. Positive inte
ference will result if inorganic halides a
not removed. Treating the GAC with
concentrated aqueous solution of nitra
ion causes competitive desorption from th
GAC of inorganic halide species an
washes inorganic halides from other su
faces. However, if the inorganic halide co
centration is greater than 20 000 times th
concentration of organic halides, the TO
results may be affected significantly. In ge
eral, this procedure may not be applicab
to samples with inorganic halide conce
trations above 500 mg Cl^-/L, based o
carbon quality testing results. Therefor
consider both the results of mineral ana
ysis for inorganic halides and the results
the carbon quality test (see 506.5, below
when intepreting results.

Halogenated organic compounds th
are weakly adsorbed on GAC are recovere
only partially. These include certain alc
hols and acids, (e.g., chloroethanol) an
such compounds as chloroacetic acid, th
can be removed from GAC by the nitra
ion. However, for most halogenated o
ganic molecules, recovery is very good; th
carbon adsorbable organic halide (CAO
therefore is a good estimate of true TO
Failure to acidify samples with nitr
acid may result in reduced adsorption e
ficiency for some halogenated organic con
pounds and may intensify the inorgan

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*Approved by Standard Methods Committee, 1985.

halide interference. Further, if the water contains residual chlorine, reduce it before adsorption to eliminate positive interference resulting from continued chlorination reactions with organic compounds adsorbed on the GAC surface or with the GAC surface itself.

Highly volatile components of the POX fraction may be lost during sampling, shipment, sample storage, sample handling, and sample preparation, or during sample adsorption. A laboratory quality-control program to insure sample integrity from time of sampling until analysis is vital. During sample filtration for the analysis of dissolved organic halogen (DOX), major losses of POX are to be expected. Therefore, analyze for POX before sample filtration and analyze for NPOX after filtering sample; the sum of POX and NPOX is true DOX. In preparing samples for DOX analysis, process a blank and a standard solution to determine effect of procedure on DOX measurement.

Granular activated carbon (GAC) used to concentrate organic material from the sample is a major source of variability in the analysis and it has a dramatic effect on the minimum detectable concentration. Ideally, GAC should have a low halide content, readily release adsorbed inorganic halides on nitrate washing, be homogeneous, and readily adsorb *all* organic halide compounds even in the presence of large excesses of other organic material. An essential element of quality control for TOX requires testing and monitoring of GAC (see Section 506.5). Nonhomogeneous carbon or carbon with a high background value affects the method reliability at low concentrations of TOX. A high and/or variable blank value raises the minimum detectable concentration. Random positive bias, in part due to the ease of carbon contamination during use, necessitates analyzing duplicates of each sample. Because carbon from different sources may vary widely in the ease of releasing inorganic halides, test for this quality before using GAC. Proper quantification also may be affected by the adsorptive capacity of the carbon. If excessive organic loading occurs, some TOX may break through and not be recovered. For this reason, make serial adsorptions of each sample portion and individual analyses.

c. Minimum detectable concentration: For nonsaline waters free of particulate matter, 5 μg organic Cl^-/L is considered a typical minimum detection limit. The minimum detectable concentration may be influenced by the analytical repeatability, equipment used, carbon quality, and the operator. Determine the detection limit for each procedure, instrument, and operator.

d. Precision and accuracy: Precision and accuracy depend on specific procedures, equipment, and analyst. Develop and routinely update precision and accuracy data for each procedure, each instrument configuration, and each analyst. Table 506:I shows sample calculations of precision expressed as the standard deviation among replicates and accuracy in the recovery of 2,4,6-trichlorophenol.

e. Sampling and storage: Collect and store samples in amber glass bottles with TFE-lined caps. If amber bottles are not available, store samples in the dark. To prepare sample bottles acid wash, rinse with deionized water, seal with aluminum foil, and bake at 400°C for at least 1 h. If bottle blanks without baking show no detectable TOX, baking may be omitted. Wash septa with detergent, rinse repeatedly in organic-free, deionized water, wrap in aluminum foil, and bake for 1 h at 100°C. Preferably use thick silicone rubber-backed TFE septa and open ring caps to produce a positive seal that prevents loss of POX and contamination. Completely fill sample bottles but take care not to volatilize any organic halogen compounds. Preserve samples that cannot be analyzed promptly by acidifying with conc nitric acid to pH 2. Refrigerate samples at 4°C with minimal

TABLE 506:I. INTRALABORATORY, SINGLE-OPERATOR, TOTAL ORGANIC HALOGEN (MICROCOLUMN PROCEDURE)—PRECISION AND ACCURACY DATA

Characteristic of Analysis	Tap Water	Tap Water + 43.5 μg Organic Chloride	Ground Water (50:1)	Wastewater	Wastewater 1000 μ Organi Chlori
Concentration determined, μg Cl^-/L:					
Replicate 1	38.5	89.0	123.6	186.0	1178.
Replicate 2	36.7	90.9	124.8	195.0	1183.
Replicate 3	43.1	88.4	125.2	195.0	1185.
Replicate 4	35.9	90.1	123.3	204.0	1196.
Replicate 5	41.1	91.7	125.3	185.0	1183.
Replicate 6	48.5	93.0	127.0	236.5	1204.
Replicate 7	52.8	97.0	123.5	204.0	1138.
Mean, μg Cl^-/L	42.37	91.5	124.7	200.8	1181.1
Standard deviation:					
μg Cl^-/L	±6.29	±3.0	±1.3	±17.47	±21.0
%	15	3	1	9	2
Value of blank + standard addition, μg Cl^-/L	—	85.87	—	—	1200.
Recovery, %	—	107	—	—	98
Error, %	—	7	—	—	2

exposure to light. If TOX is to be determined at the time of sampling, reduce any residual chlorine by adding sodium sulfite crystals (minimum: 5 mg/L).

2. Apparatus

a. Adsorption assembly,† including pressurized sample reservoir, GAC-packed adsorption columns, column housings, gas-pressure regulators, class A volumetric flasks, and nitrate solution reservoir. See Figure 506:1. In particular, note the following:

1) *Noncombustible insulating material‡ (microcolumn method only):* Form into plugs to hold GAC in columns. CAUTION: *Do not touch with fingers.*

2) *Granular activated carbon (GAC) col-*

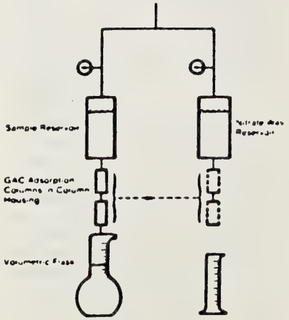

Figure 506:1. Adsorption assembly.

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†Xertex-Dohrmann AD-2 or equivalent.
‡Cerafil, Manville Co., or equivalent.

umns (microcolumn method only): Pack 40 ± 5 mg GAC (¶ 3*k*) into glass tubing approximately 2 mm ID × 6 mm OD × 50 mm long. CAUTION: *Protect these columns from all sources of halogenated organic vapors.*

b. Analyzer assembly,[§] including carrier gas source, boat sampler, multizone pyrolysis furnace, microcoulometer, integrator, vacuum source, and purging apparatus.

c. Chart recorder.

3. Reagents and Materials

Use ACS reagent-grade chemicals. Other grades may be used if it can be demonstrated that the reagent is of sufficiently high purity to permit its use without lessening accuracy of the determination.

a. Carbon dioxide, purity 99.99%.

b. Oxygen, purity 99.99%.

c. Aqueous acetic acid, 70%: Dilute 7 volumes of conc acetic acid with 3 volumes of water.

d. Sodium chloride standard, NaCl: Dissolve 0.1648 g NaCl and dilute to 100 mL with reagent water; 1 µL = 1 µg Cl$^-$.

e. Ammonium chloride standard, NH$_4$Cl: Dissolve 0.1509 g NH$_4$Cl and dilute to 100 mL with reagent water; 1 µL = 1 µg Cl$^-$.

f. Trichlorophenol stock solution: Dissolve 1.856 g trichlorophenol and dilute to 100 mL with methanol; 1 µL = 10 µg Cl$^-$.

g. Trichlorophenol standard solution: Make a 1:20 dilution of the trichlorophenol stock solution with methanol; 1 µL = 0.5 µg Cl$^-$.

h. Chloroform standard solution, CHCl$_3$: Dilute 100 mg CHCl$_3$ to 100 mL with methanol.

i. Blank standard: Use reagent water. Reagent water preferably is carbon-filtered, deionized water that has been heated and purged.

j. Nitrate wash solution, 0.08*N*: Dilute 8.2 g KNO$_3$ to 1000 mL with reagent water. Adjust to pH 2 with HNO$_3$. 1 L = 5000 mg NO$_3^-$.

k. Granular activated carbon, 100-200 mesh: Ideally use GAC having a very low apparent halide background that readily releases adsorbed inorganic halides on nitrate washing, and reliably adsorbs organic halides in the presence of a large excess or other organics.[‖] CAUTION: *Protect GAC from contact with halogenated organic vapors.*

l. Sodium sulfite, Na$_2$SO$_3$, crystals.

m. Nitric acid, HNO$_3$, conc.

n. Humic acid.

4. Procedure

Use either the microcolumn (4*a*) or batch adsorption (4*b*) method. The microcolumn method utilizes small glass columns packed with GAC through which the sample is passed under positive pressure to adsorb the organic halogen compounds. The batch adsorption method directly measures POX. A small quantity of GAC then is added to the NPOX portion. After stirring, GAC is removed by filtration and analyzed.

a. Microcolumn procedure:

1) Apparatus setup—Adjust equipment in accordance with the manufacturer's instructions.

2) Sample pretreatment for TOX analysis—Adjust sample pH to 2 with HNO$_3$. If dissolved organic halogen (DOX) is to be measured, filter sample through a glass-fiber filter using vacuum. Also filter a filtration blank and standard. Analyze these to determine the contribution of filtration to the organic halogen measurement. Vacuum filtration will cause some loss of volatile organic halogen. Preferably analyze for POX before filtration and NPOX after filtration or use pressure filtration to minimize losses.

[§] Xertex-Dohrmann DX-20 or equivalent.

[‖] Westvaco or Calgon Filtrasorb 400 or equivalent.

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3) Sample adsorption—Transfer a representative portion of sample to the sample reservoir with two GAC adsorption columns in series attached by the column housings to the reservoir outlet (see Figure 506:1). Seal and pressurize the reservoir. Adjust pressure to produce a filtration rate of about 3 mL/min. Collect filtrate in a volumetric flask. When the desired volume has been filtered, depressurize the reservoir, detach the GAC housings and columns, and drain excess water in the reservoir into a waste receptacle. Vary volume filtered to produce optimum quantities of adsorbed TOX on the columns. Suggested volumes are as follows:

Volume Filtered *mL*	Instrument Optimum Range *µg Cl$^-$*	Conc of TOX in Waters *µg/L*
100	0.5–25	5–250
50	5–25	100–500
25	5–25	200–1000

If possible, avoid filtering volumes greater than 100 mL because the maximum adsorptive capacity of the GAC may be exceeded, leading to carbon breakthrough and loss of TOX. Larger sample volumes filtered lead to an increased quantity of inorganic halide accumulated on the GAC and may result in a positive interference. Do not use a sample less than 25 mL to minimize volumetric errors. For samples exceeding 1000 µg TOX/L, dilute before adsorption.

Where the compound or class of compounds being analyzed is known, determine percent recovery by analysis of standard solutions processed in the same manner.

4) Inorganic halide removal—Attach columns through which sample has been filtered in series on the nitrate wash reservoir and filter 2 mL NO$_3^-$ solution at a rate of approximately 1 mL/min.

5) Sample analysis—After concentrating sample on GAC and removing inorgar halogens by nitrate washing, pyrolyze co tents of each microcolumn and determi organic halogen content. Remove top gla microcolumn from the column housin taking care not to contaminate the samp with inorganic halides. Using a clean eje tor rod, eject the GAC and noncombustib insulating material plugs into the samp boat. Place ejector rod on the plug of th effluent end of the carbon microcolumn a place the influent end of the carbon m crocolumn in the quartz boat first. Se sample inlet tube and let instrument st bilize. After NO$_3^-$ wash avoid contact wi inorganic halides such as the chloride fro perspiration on the hands or contaminat bench surfaces. Wash hands frequently, e pecially after eating, and clean work ar with deionized water often.

Pyrolyze the GAC and determine hali content. Repeat for each microcolumn.

6) Preparation and analysis of calibr tion standard—Place a single GAC micr column in a column housing and attach the nitrate wash reservoir of the adsorptic unit. Filter 2 mL nitrate solution throug column at rate of 1 mL/min. Remove co umn housing from reservoir and, takir care not to contaminate GAC column wi inorganic chloride, inject desired amou of working standard solution into the ce ter of the GAC column. Eject and pyroly as instructed above.

b. Batch adsorption procedure:

1) Apparatus setup—Adjust equipme in accordance with the manufacturer's i structions.

2) Sample pretreatment—Adjust samp pH to 2 with conc HNO$_3$.

3) POX determination[#]—Select samp volume by comparing expected POX valu (if known) with the optimum instrume range. Using a gas-tight syringe, inject sa ple through the septum into the purge ve

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[#] Xertex-Dohrmann DX-20 Purge Assembly or equivalent.

sel and purge as recommended by the equipment manufacturer. To compare POX values from different laboratories standardized purging is essential. Adjust instrument temperature, purge rate, and purge time to just produce complete purging of bromoform using a bromoform standard. Take replicate samples from different sample bottles to minimize volatilization losses.

4) NPOX determination—Prepare carbon suspension by adding high-quality carbon to high-purity, deionized, GAC-filtered water to produce a uniform suspension of 10 mg carbon/mL. To an erlenmeyer flask, transfer prepurged sample of optimum size from a purging flask standardized in the same manner as the instrument's purging vessel. Add 20 mg activated carbon (2 mL carbon suspension). Using a high-speed mixer (20 000 rpm), stir for 45 min in an organohalide vapor-free environment. Filter through a membrane filter under vacuum and collect filtrate. Remove flask containing filtrate. Wash carbon cake and filter with 10 mL NO_3^- wash solution. Add portions of wash solution serially to keep carbon and NO_3^- solution in contact for 15 min. Using clean instruments, transfer carbon cake and membrane filter to pyrolysis unit sample boat. Let instrument stabilize, pyrolyze, and determine the halide content of the first serial filter.

Add 20 mg more carbon to filtrate in erlenmeyer flask. Repeat carbon mixing, filtering, and washing procedures. Pyrolyze and determine halide content of second serial filter. If the second value is greater than 10% of the total value (first plus second), filter an additional sample portion.

5. Quality Control

a. Carbon quality: Prepare GAC by milling and sieving high-quality activated carbon. Use only 100- to 200-mesh carbon in the microcolumn method. During preparation, take care not to expose the carbon to organic vapors. Use of a clean room is helpful. Prepare only small quantities (a month's supply or less) at one time. Discard the GAC if its TOX background concentration has increased significantly from the time of preparation or if the background is greater than 1 μg apparent organic Cl^-/40 mg GAC. Uniformity of GAC is important; therefore, after sieving small portions, combine and mix thoroughly. Transfer representative portions to clean glass bottles with rubber-backed TFE septa and open ring caps. Store bottles in a gas-purged, evacuated, sealed desiccator.

Test each newly prepared batch of GAC to insure adequate quality before use. Do not use carbon not meeting the guidelines outlined below.

1) Pyrolyze replicate 40-mg portions of GAC. The apparent background content should be less than 1.00 μg organic Cl^-/40 mg GAC.

2) Wash replicate 40-mg GAC portions with nitrate solution according to the method. Reject carbon if the increase in apparent organic halogen exceeds 0.10 μg/40 mg GAC.

3) Filter replicate 100-mL portions of solutions containing 100, 500, and 1000 mg inorganic Cl^-/L deionized water. Wash with nitrate solution and analyze. The apparent organic halogen yield should not increase by more than 0.50 μg over the value determined in 2) above. A greater increase indicates significant interference at that concentration.

4) Prepare an absorption test standard solution in deionized water to contain 10 mg organic carbon (as humic acids or equivalent)/L and an organic halide concentration of 10 mg organic chloride (from 2,4,6-trichlorophenol)/L. Prepare a blank solution containing only the 10 mg organic carbon. Adsorb, nitrate wash, and analyze replicate 100-mL portions of these solutions. Directly inject 10 μg organic chloride (from 2,4,6-trichlorophenol) onto nitrate-washed 40-mg GAC microcolumns, in replicate. Analyze replicate

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method blanks. Recovery of the *aqueous* organic chloride should be ≥ 95% on the first microcolumn or filter and 5% or less on the second. Total recovery of organic chloride from water should be 95% or more (after subtraction of the organic carbon blank) of the amount applied.

b. Serial adsorption: Each aqueous standard and sample is serially adsorbed on GAC in both procedures given above. Of the net organic halide, 90% or more should be adsorbed on the first GAC portion and the remaining 10% or less on the second. If, upon separate analysis of the two serial GAC portions, the second shows more than 10% of the net (after subtracting the method blank), reanalyze sample. Inorganic halogen interference or organic breakthrough are the most common reasons for a high second GAC value. Sample dilution before adsorption may improve recovery on the first GAC in series, but the minimum detectable concentration will be affected.

c. Standards: Use 2,4,6-trichlorophenol or an equivalent chlorinated organic compound as a standard for routine TOX analysis. For POX analysis, chloroform is the suggested standard. For quality control in the POX analysis, to insure proper and complete purging, use bromoform. Test specific compounds representative of the various classes of halogenated organic compounds to determine recovery from aqueous solutions. In situations where the compounds constituting the TOX are known, use standards of these compounds.

The standards used in routine analysis, quality control testing, and isolating specific causes during corrective maintenance include:

1) Sodium chloride standard (¶ 3*d*)—Use to check functioning of the titration cell and microcoulometer by injecting directly into the acetic acid solution of the titration cell. By examining the height and shape of the peak produced on the chart recorder and from the integrated value,

problems associated with the cell and co
lometer may be isolated. Use this standa
at startup each day and after cell cleani
throughout the day. At daily startup co
secutive duplicates should be within 3%
the historical mean. Depending on samp
loading and number of analyses performe
it may be necessary to clean the titrati
cell several times per day. After cleanin
cell performance may be very unstab
therefore, inject a single NaCl standard b
fore analyzing an instrument calibrati
standard [see 4) below]. Do *not* introdu
NaCl standards into the pyrolysis furna
by application to the sample boat.

2) Ammonium chloride standard
3*e*)—Apply this standard to the samp
boat to check for loss of halide in the p
rolysis furnace and entrance of the titrati
cell. When injection of a NaCl standa
indicates proper titration cell and micr
coulometer function but the recovery of t
calibration standard is poor, suspect eith
poor conversion of organic chloride to h
drogen chloride or loss of hydrogen hali
after conversion but before partitioni
into the cell solution. To isolate the possib
loss of hydrogen halides inject NH_4
standard directly onto the quartz samp
boat. Recovery should be better than 95
with a single peak of uniform shape pr
duced. Use only a new quartz sample bo
free of any residue; an encrusted boat dr
matically reduces recovery. Use this stan
ard for corrective maintenance proble
isolation but not for routine analyses.

3) Aqueous organic chloride stan
ards—For the POX analysis use aqueo
chloroform solutions for instrument ca
bration. Also for POX analysis use
aqueous bromoform standard to insu
proper operating conditions. In assessin
carbon quality measure recovery of 2,4,
trichlorophenol from water containin
humic acid to determine the carbon a
sorption efficiency. In addition, evalua
the effect of sample matrix on accuracy b
a standard addition into the sample befo

adsorption. Use recovery of model compounds representative of the various classes of organic halide compounds to evaluate validity of methods and instruments used.

4) Instrument calibration standard—Direct injection of trichlorophenol working standard onto the nitrate-washed method blank in concentrations over the working range of the instrument determines linearity and calibration of the analyzer module. After checking for proper microcoulometer function by injecting NaCl standard, pyrolyze duplicate instrument calibration standards and then duplicate method blanks. The net response to the calibration standards should be within 3% of the calibration curve value. Analyze additional instrument calibration standards after each eight sample pyrolyses and after cleaning the titration cell.

5) Calibration curve—Develop a standard curve by analyzing instrument calibration standards over the dynamic range of the microcoulometer. This dynamic range typically is from 0.5 to 50 µg chloride, but will vary between microcoulometers and titration cells. Because of the limited throughput of the TOX procedure, use single-instrument calibration standards at 50, 40, 30, 20, 15, 10, 5, 2.5, and 0.5 µg organic chloride to construct a standard curve after changes in an instrument's configuration, such as replacement of a titration cell or major instrument maintenance. Daily, analyze additional replicates of several instrument calibration standards to insure reproducibility, linearity, and proper function of the instrumentation and procedures. Select standard concentrations in the range of samples to be analyzed that day.

d. Standard addition recovery: During routine analyses, ideally make standard additions to every tenth sample. Recovery of 90% or more of the added amount indicates that the analyses are in control.

e. Blanks: High precision and accuracy of the background or blank value is important to the accurate measurement of TOX. Make blank measurements daily. Blanks that may be required are:

1) System blank—Analyze organic-free reagent water. The blank should have less than the minimum detectable concentration. Use this blank to insure that the equipment and procedures are not contributing to the TOX.

2) Method blank—Analyze GAC that has been nitrate-washed. Analyze duplicate method blanks daily before sample analysis and after each eight sample pyrolyses.

3) Standard blank—Analyze reagent water to determine the blank for standards.

4) Purgeable organic halogen blank—Analyze organic-free, pre-purged, reagent water to determine the POX blank.

f. Sample duplicates: To evaluate random bias analyze replicates of each sample. Establish acceptable control limits.

6. Calculation

Calculate the net organic chloride content (C_4) of each filtered replicate of each sample and standard:

$$C_4 = \frac{C_1 - C_3 + C_2 - C_3}{V}$$

where:

C_1 = organic Cl⁻ on the first column or filter, µg.
C_2 = organic Cl⁻ on the second column or filter, µg.
C_3 = mean of method blanks on the same day and same instrument, µg Cl⁻,
C_4 = uncorrected net organic Cl⁻ of filtered sample, µg organic Cl⁻/L, and
V = volume of sample filtered, L.

If applicable, calculate net purgeable organic Cl⁻ content (P_3):

$$P_3 = \frac{P_1 - P_2}{V}$$

where:

P_1 = sample purgeable organic Cl⁻, µg.
P_2 = blank purgeable organic Cl⁻, µg.

P_3 = uncorrected net purgeable organic Cl⁻, µg Cl⁻/L, and
V = volume of sample or standard purged, L.

Determine the linear regression of instrument calibration standard curves for each instrument configuration. Update this linear regression daily by including the standard points analyzed on that day. Calculate the corrected organic chloride concentration for each replicate of each sample by substituting the net organic chloride content (C_4 or P_3) of each sample replicate into the appropriate linear regression equation.

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507 OXYGEN DEMAND (BIOCHEMICAL)*

1. Discussion

The biochemical oxygen demand (BOD) determination is an empirical test in which standardized laboratory procedures are used to determine the relative oxygen requirements of wastewaters, effluents, and polluted waters. The test measures the oxygen required for the biochemical degradation of organic material (carbonaceous demand) and the oxygen used to oxidize inorganic material such as sulfides and ferrous iron. It also may measure the oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand) unless their oxidation is prevented by an inhibitor.

The method consists of placing a sample in a full, airtight bottle and incubating bottle under specified conditions for a s cific time. Dissolved oxygen (DO) is me ured initially and after incubation. T BOD is computed from the difference tween initial and final DO.

The bottle size, incubation temperat and incubation period are all specifi Most wastewaters contain more oxyg demanding materials than the amount DO available in air-saturated water. The fore, it is necessary to dilute the sam before incubation to bring the oxygen mand and supply into appropriate balan Because bacterial growth requires nutrie such as nitrogen, phosphorus, and tr metals, these are added to the dilut water, which is buffered to ensure that pH of the incubated sample remains i

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*Approved by Standard Methods Committee, 1981.

Appendix B

WHMIS Guidelines

Occupational Health & Safety
BULLETIN

22 February, 1988

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

Legislation

The development of WHMIS legislation has progressed very rapidly over the past few months.

The federal WHMIS legislation deals with the supplier aspects of the system. Publication of the Controlled Products Regulations, the Ingredient Disclosure List, and the Hazardous Materials Information Review Regulation in Part II of the Canada Gazette on January 20 arked its completion. These regulations, as well as the Hazards Products Act, are summarized on page 7 of this package.

A model occupational health and safety (OSH) regulation to deal with employer and worker aspects of WHMIS, was developed for use by the individual occupational health and safety jurisdictions when developing their own WHMIS regulations. A draft Alberta WHMIS regulation was developed on the basis of this model. It was circulated for a public review period which ended on December 31, 1987. Comments received as a result of the public review, as well as comments on the model regulation from across the country, are currently under study.

Seminars

Staff of the Occupational Hygiene Branch have appeared as guest speakers on WHMIS at numerous conferences, and at industry and association meetings. If your group would like to have a WHMIS speaker at its next meeting, call Deborah at 427-2687.

The Education and Program Development Branch has organized introductory seminars on WHMIS in several cities and towns, when requested to do so. If you're interested in having a WHMIS seminar in your area, call Education and Program Development at 427-4790 in Edmonton or 297-7282 in Calgary. We'll do our best to satisfy your request.

(SEE OVER)

Alberta
COMMUNITY AND
OCCUPATIONAL HEALTH
Occupational Health and Safety Division

Seminars on specific aspects of WHMIS are currently being planned. Your suggestions for specific WHMIS seminar topics are welcome. Call Deborah.

Information Package

Material in this information package has been revised and updated to make a fairly complete, general summary of WHMIS. Future issues will deal with specific aspects of WHMIS in much greater detail and will not include this background information. This issue, along with future ones, could be collected to produce a basic WHMIS manual.

Copies of the information packages will be sent automatically to persons on our WHMIS mailing list. If you know anyone who should be added, please get them to call or write to us at:

WHMIS Coordinator
Occupational Health and Safety Division
ALBERTA COMMUNITY AND OCCUPATIONAL HEALTH
10709 - Jasper Avenue
Edmonton, Alberta T5J 3N3
Tel: (403) 427-2687

For further information regarding WHMIS, ask to speak with Dave Gibson or Deborah Smith.

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM
(WHMIS)

ALBERTA INFORMATION PACKAGE

PART 1. OVERVIEW

FEBRUARY 10, 1988

ALBERTA INFORMATION PACKAGE
WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

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Revised 88-02-10

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

SUMMARY

Ministers Responsible for Occupational Health and Safety met in Toronto, Ontario on December 16, 1986 for the last of a series of meetings to discuss the Workplace Hazardous Materials Information System (WHMIS). They reached agreement on the principle of WHMIS and on the intention to proceed with implementation of the system. (See Attachment #1 - Communique.)

Extensive consultation among industry and labour representatives, and federal, provincial and territorial governments has led to a national consensus respecting WHMIS. WHMIS is a pan-Canadian hazard communication system consisting of a triad of elements: a label, a material safety data sheet and a worker information/training program. It will form a fundamental part of the worker's right to know about hazardous products used in the workplace.

Under an amendment to the federal Hazardous Products Act, WHMIS will require, as a condition of sale, that suppliers (including manufacturers, processors, packagers and importers) classify hazardous materials which they supply to workplaces according to standard hazard classes. Hazardous materials will bear a standardized label. WHMIS supplier labels will have material identifiers, hazard symbols, risk phrases, precautionary statements and first aid measures--all based on the hazardous properties of the product. This system will also require suppliers to develop and distribute Material Safety Data Sheets (MSDSs) with more detailed health and safety information for all hazardous materials sold to workplaces.

Employers will be responsible for ensuring that hazardous materials used at their workplaces are properly labelled and that MSDSs for those materials are readily available. This responsibility will apply to materials manufactured at the workplace as well as to materials obtained from suppliers. Employers will also be responsible for training workers so that they will be able to understand the WHMIS labels and MSDSs and apply the information to their work practices.

Industry and labour associations have expressed a strong commitment to WHMIS. The Occupational Health and Safety Division of Alberta Community and Occupational Health has been a strong supporter of WHMIS throughout its development and is very pleased with the continuing progress toward implementation. (See Attachment #2 - Ministerial News Release.)

WHAT PROBLEMS IS WHMIS TRYING TO SOLVE?

- Unlabelled chemicals at workplaces.
- Lack of awareness by employers and workers about the identity, properties, and hazards of chemicals they are using.
- Inadequate information provided by suppliers to employers and workers respecting the hazardous properties of materials used at work sites and the precautions to be taken.
- Potential adverse consequences of inconsistent requirements between Canadian jurisdictions.

WHAT IS WHMIS?

- Pan-Canadian hazard communication system for transmitting information respecting hazardous materials used at workplaces.
- Triad of key elements: a label, a material safety data sheet (MSDS), and a worker information/training program.
- Control of suppliers and importers, as a condition of sale, through the (federal) Hazardous Products Act (HPA). The HPA which is administered by Consumer and Corporate Affairs Canada, will be enforced by provincial, territorial and federal occupational safety and health (OSH) agencies.
- Requirement that suppliers and importers classify hazardous materials label their containers and supply MSDSs to purchasers.
- Regulation of user workplaces by new regulations under provincial, territorial and federal occupational health and safety statutes.
- Requirement that employers at user workplaces ensure the presence of WHMIS labels and MSDSs on hazardous materials they purchase, and provide worker education.
- Requirement that workplaces producing hazardous materials meet WHMIS requirements for those materials.

KEY ISSUES

- The system has been designed to be national in scope and apply equally to domestic products and imports. It must not impose a non-tariff trade barrier.
- Workers' "right to know" respecting the identity and hazards of materials used must be recognized.
- Legitimate confidential business information (e.g., trade secret ingredient, supplier identity, etc.) must be protected. The Screening Division of the Hazardous Materials Information Review Commission (HMIRC) will perform this function.
- MSDSs with information legimately withheld on the basis of confidential business information must be independently reviewed for accuracy and completeness of hazard information. The Screening Division of the HMIRC will perform this function as well.
- Appeals of screening agency decisions regarding confidential business information claims will be heard by a tripartite board. The Appeals Division of the HMIRC will administer the appeal process.
- Interjurisdictional cooperation will be required for enforcement.
- Adherence to the national tripartite consensus (WHMIS Steering Committee Report, April, 1985) is critical. All parties have agreed that the whole system, not just parts of it, will be implemented.

IMPACT ON THE PUBLIC

- All users, from janitorial services to major chemical manufacturers will be positively affected by the availability of health and safety information of a higher quality and on more products than is currently in circulation.
- Compliance with existing occupational health and safety requirements will be easier for most workplaces because materials will be labeled and MSDSs will be supplied to workplaces with products as they are purchased.
- Supplier industries will have uniform standards to meet across Canada.
- Workers' Compensation costs will be reduced as worker exposures to hazardous chemicals and accidents involving chemicals decline.
- Health care costs for treatment of conditions related to worker exposure to hazardous chemicals, including long-term degenerative diseases (eg., liver, kidney, central nervous system, cancers) will be reduced.

WHMIS HAZARD CLASSES

- Entry into WHMIS is triggered by a material meeting the criteria for one or more of the following hazard classes:
    - compressed gas
    - flammable and combustible material
    - oxidizing material
    - poisonous and infectious material
    - corrosive material
    - dangerously reactive material.

  Materials which meet any of these criteria are CONTROLLED PRODUCTS.

- Classification criteria for WHMIS are consistent with classification criteria for Transportation of Dangerous Goods (TDG) regulations, with the addition of chronic toxicity to the poisonous/infectious material classification.

- Consumer products, foods, drugs, pesticides, and radioactive materials which are regulated and labelled under other statutes are excluded from the WHMIS labelling and MSDS requirements, but will be harmonized into the system over the next several years.

- Manufactured articles, wood and wood products, and tobacco and tobacco products, are excluded from WHMIS.

WHMIS SUPPLIER LABELS

- Required on controlled products, as a condition of sale.

- Must include the following information:
    - product identifier
    - supplier identifier
    - reference to the availability of a material safety data sheet.
    - hazard symbol(s) (See Attachment #3)
    - risk phrase(s)
    - precautionary measure(s) } where the container has a capacity of more than 100 ml
    - first aid measure(s)

- Must be edged with a distinctive WHMIS border in a color that contrasts with the color of the background to which it is attached.

- Must be readily legible.

- Must be written in both official languages. Alternatively, two labels, one in English and one in French, may be used.

- Certain exemptions are permitted for laboratory reagent chemicals, laboratory samples, materials shipped in bulk, and materials packaged as multi-container shipments.

- See Attachment #4 for a model supplier label.

WHMIS MATERIAL SAFETY DATA SHEETS (MSDSs)

- Suppliers are required, as a condition of sale, to provide MSDSs with controlled products.

- Must contain information in each of 9 major categories:
    - hazardous ingredient(s)
    - person(s) responsible and date of preparation of the MSDS.
    - product information, including manufacturer's name and emergency telephone number
    - physical data
    - fire and explosion hazard
    - reactivity data
    - toxicological properties
    - preventive measures
    - first aid measures

- Must contain information for each of the 9 major categories. "Not applicable", "information not available", "not tested", etc. may be used if appropriate, but no category may be left blank.

- Must contain such further hazard information of which the supplier is aware or ought reasonably to be aware.

- Must disclose the identity of ingredients present at a concentration greater than 1% by weight unless the ingredient is a lung sensitizer, carcinogen, mutagen, teratogen or reproductive toxin, in which case disclosure down to 0.1% by weight is required.

- Must reveal ingredients which are listed on the Ingredient Disclosure List (IDL) if they are present in the controlled product in concentrations greater than those specified on the IDL.

- Must reveal ingredients which the supplier has reason to believe may be harmful, or whose toxicological properties are unknown.

- Must contain detail to the extent that information is available. There is no requirement for additional toxiological testing of the product.

- Certain exemptions to/modifications of the requirements regarding the disclosure of ingredient concentrations and supplier identity, are permitted in certain circumstances.

- Must be developed by the supplier in both official languages, and provided to the purchaser in his choice of English or French.

WORKER EDUCATION

- Developed in order to ensure that workers benefit from the information that suppliers and employers are required to provide through product labels and MSDSs.

- Must be provided for workers who work with or in proximity to controlled products.

- Must be developed in conjunction with mandated joint worksite health and safety committees.

- Must be worksite specific.

- Must be reviewed annually or more frequently if new hazard information becomes available or if process changes make the existing worker education program outdated. These reviews must be conducted in conjunction with joint worksite health and safety committees, where these are mandated.

- Must include, with regard to the controlled products a worker works with or in proximity to:
  - Hazard information provided by the supplier.
  - Additional hazard information of which the employer is aware or ought reasonably to be aware.
  - The content required on a supplier label and on an MSDS, and the purpose and significance of that information.
  - Procedures for the safe use, handling, storage, and disposal of the controlled products.
  - Procedures regarding fugitive emissions of controlled products.
  - Procedures regarding emergencies involving controlled products.

- Must be effective in allowing workers to apply the training to protect their health and safety.

CONFIDENTIAL BUSINESS INFORMATION

- Genuine trade secrets will be protected.

- Claims of confidential business information will be evaluated against objective criteria.

- A Hazardous Materials Information Review Commission (HMIRC) has been established to deal with claims of confidential business information. It is a federal Crown Corporation with membership representing industry and labour, and federal, provincial and territorial governments.

- The HMIRC will have two divisions:
  - Screening Division:
    - validates/rejects claims of confidential business information.
    - reviews MSDSs for products which are the subject of confidential business information claims, for adequacy of hazard information.

  - Appeals Division:
    - establishes tripartite appeals panels to hear appeals to decisions of the Screening Division.

- Appeals will be held in the province or territory where the material is produced or imported.

- Confidential business information handled by the Commission will not be released through 'freedom of access to information' legislation.

- Confidential business information must be revealed to a medical professional if it is required for diagnosis or treatment in an emergency situation.

WHMIS LEGISLATION

- Coordinated system of federal, provincial, and territorial legislation.

- Supplier requirements, the Ingredient Disclosure List, the establishment and operation of the HMIRC, and employer and worker aspects of WHMIS at federal worksites, are governed by federal legislation.

- Supplier requirements are contained in the Hazardous Products Act (Part II) and the Controlled Products Regulations. These include:
  - exemptions from WHMIS, including products which are exempted from some or all of the WHMIS requirements, and situations in which some of the WHMIS requirements are reduced or modified,
  - requirement for labels and MSDSs for controlled products, as a condition of sale,
  - definition of and criteria for controlled products, and
  - testing procedures for determining certain physical data required on MSDSs.

- The Ingredient Disclosure List is a list of about 1700 chemicals whose identity and concentration must revealed on a MSDS.

- Employer and worker aspects of WHMIS at federal worksites are governed by the Canada Labour Code and the Canada Occupational Health and Safety Regulations.

- The HMIRC has been established and is operated under the authority of the (federal) Hazardous Materials Information Review Act. Criteria for the validation of a confidential business information claim are contained in the Hazardous Materials Information Review Regulations.

- Employer and worker (user) aspects of WHMIS at all non-federal worksites are governed by provincial/territorial regulations. These individual provincial and territorial regulations are based on a model occupational health and safety regulation which was developed by all of the occupational health and safety jurisdictions in consultation with labour and industry representatives.

HISTORICAL PERSPECTIVE

- 1981-82 - A labelling proposal was presented to Deputy Ministers of Labour by the OSH Committee of Canadian Association of Administrators of Labour Legislation (CAALL). This proposal resulted in a feasibility study being conducted. It identified the need for:
  - a national system using the federal Hazardous Products Act for regulation of suppliers (including importers).
  - MSDSs labels, and worker education.

  The feasibility study was accepted. CAALL mandated consultation with industry and labour to design a workable system.

- 1982-1985 - The philosophic basis for the system was developed by the WHMIS Steering Committee and its various working groups. Representatives from industry and labour groups, and the federal, provincial and territorial governments participated and achieved consensus.

- 1985 - WHMIS Steering Committee report published. Jurisdictional review was initiated by CAALL deputy ministers.

- May 1986 - The decision to move toward implementation was made by the CAALL deputy ministers, following interjurisdictional meetings of senior officials.

- June-September 1986 - An Implementation Coordinating Committee (ICC) of federal, provincial and territorial officials was established to develop policy and legislative frameworks for federal and provincial implementation. Draft federal (supplier) regulations and model Occupational Health and Safety (user) regulations were developed.

- September to December 1986 - The system developed by ICC was considered feasible by CAALL deputy ministers. Ministers responsible for occupational health and safety reached agreement on:
  - the system, in principle, including the decision to proceed with implementation,
  - confidential business information screening and appeals mechanism, and
  - sharing responsibilities and costs of operating WHMIS. (See Attachment #1 - Communique.)

- January - June 1987 - Amendments to the federal Hazardous Products Act to establish WHMIS, and the Hazardous Materials Information Review Act, were drafted. These were reviewed by provincial, territorial, labour and industry representatives.

- Draft Memoranda of Understanding between the jurisdictions for implementation and enforcement of WHMIS were developed.

- June 30, 1987 - Bill C-70, the federal bill to implement WHMIS, including amendments to the Hazardous Products Act and the Canada Labour Code and an Act to establish a Hazardous Materials Information Review Commission, was passed.

- June - August, 1987
  - The draft Controlled Products Regulations were refined.
  - The draft Hazardous Materials Information Review Regulations were refined.
  - The draft model Occupational Health and Safety Regulation was refined.
- September 26, 1987 - The Controlled Products Regulations (under the federal Hazardous Products Act) and the Hazardous Materials Information Review regulations distributed for 1 month of public review.
- October, 1987 - The model occupational health and safety regulations for user worksites were completed and sent to the individual OSH jurisdictions for use in drafting their WHMIS legislation.
- November, 1987 - The proposed Alberta Regulation respecting WHMIS was circulated for public review.
- January, 1987 - The Controlled Products Regulation and the Hazardous Materials Information Review Regulations were finalized (published in Part II, Canada Gazette).

D. Gibson/D. Smith
Rev. 88-02-10

Attachment #1

Communique

FEDERAL-PROVINCIAL-TERRITORIAL MEETING OF MINISTERS RESPONSIBLE FOR OCCUPATIONAL HEALTH AND SAFETY

AGREEMENT ON WHMIS REACHED AT MEETING OF FEDERAL-PROVINCIAL-TERRITORIAL MINISTERS RESPONSIBLE FOR OCCUPATIONAL HEALTH AND SAFETY

Toronto, 16 December, 1986 -- Federal-Provincial-Territorial Ministers responsible for occupational health and safety today agreed to proceed with the implementation of the Workplace Hazardous Materials Information System (WHMIS).

The meeting today concluded discussions on the details of the agreement focusing on the establishment of the Trade Secrets Mechanism. WHMIS makes provision for the protection of trade secrets by suppliers. Trade secret claims will be screened and workers and suppliers may appeal decisions.

The Trade Secrets Mechanism will be governed by a multi-partite board of directors having government, industry and labour representation. It will have a screening function, an appeal process and will be self-financing. There will be consultation with labour and industry on the structure and formation of the Board of Directors. The Ministers will review the process and operation of the Trade Secrets Mechanism after one year.

When implemented, WHMIS will be the first national system of this type in Canada. It is a fundamental part of the worker's right-to-know about hazardous substances in the workplace. WHMIS is designed to provide a uniform, national means of informing workers of hazards in the workplace by three means:

- comprehensive labelling of materials;
- provision of data sheets containing detailed information about the properties of substances, their potential hazards, and ways and means of dealing with such hazards;
- effective training of workers and supervisors who use these substances in the workplace.

WHMIS was developed through a multipartite process by representatives of business, labour and the federal-provincial-territorial governments. The Ministers are especially thankful to labour and industry for their participation and assistance in developing WHMIS.

December 16, 1986
Toronto, Ontario.

Attachment #2

Alberta NEWS RELEASE

GOVERNMENT OF ALBERTA

NEW WORKPLACE PROTECTION SYSTEM MOVES AHEAD

Edmonton, June 22, 1987 -- Jim Dinning, Minister of Community and Occupational Health, today expressed pleasure in a significant step forward being made in the implementation of a new workplace hazard warning program.

The Federal Government today introduced a Bill to implement the Workplace Hazardous Materials Information System (WHMIS). When in place, WHMIS will be the first Canada-wide system of its type, and will represent the worker's fundamental right to know about hazards in the workplace.

Dinning praised the efforts made at both the provincial and federal levels of government which resulted in the development of this new program. "Without the co-operation of labour, industry and government this innovative program of worker protection would not have come about," he said.

The WHMIS program is designed to provide a uniform, national means of informing workers about hazardous substances in their places of work. The program will use three approaches:

- comprehensive labelling of all packages, containers and vessels containing potentially hazardous substances,
- provision of safety data sheets containing detailed information about the substances, and
- training of workers on the recognition and safe use of hazardous substances.

The WHMIS program will supplement, on a national basis, what is already required in Alberta under the Chemical Hazards Regulation. Ammendments to Alberta regulations will be necessary to deal with work sites using hazardous materials and worker education.

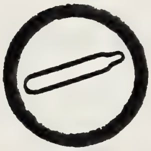
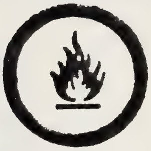
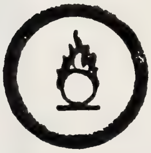
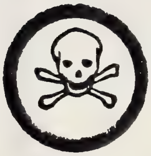
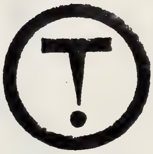
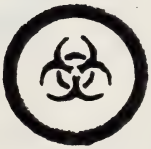
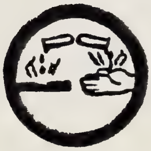
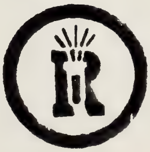
Dinning said, "I am extremely pleased that this program will soon be in place, and that the Alberta government played a key role in its development. It further outlines the commitment of this government to furthering the health and safety of Alberta workers."

Reference:
Office of the Minister
427-2331

Dave Gibson
Director, Occupational Hygiene
427-2687

Attachment #3

HAZARD SYMBOLS

Column I Classes and Divisions	Column II Hazard Symbols
Class A - Compressed Gas	
Class B - Flammable and Combustible Material	
Class C - Oxidizing Material	
Class D - Poisonous and Infectious Material	
1. Materials Causing Immediate and Serious Toxic Effects	
2. Materials Causing Other Toxic Effects	
3. Biohazardous Infectious Material	
Class E - Corrosive Material	
Class F - Dangerously Reactive Material	

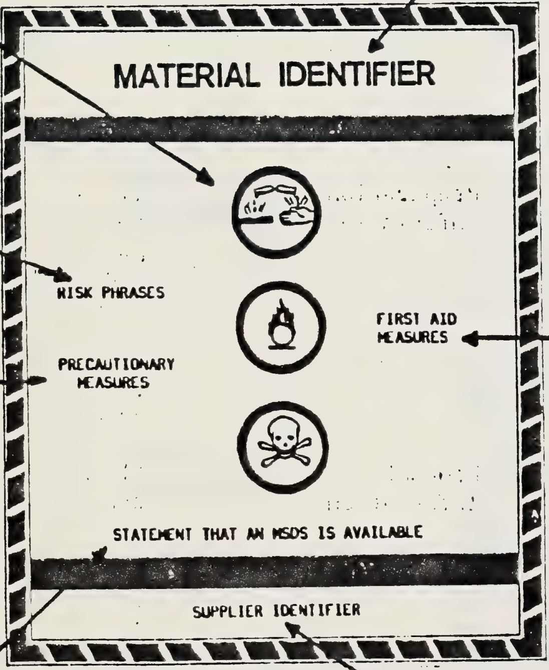
Attachment #4

SUPPLIER LABEL

A MODEL

Hazard Symbol: A pictogram in a circular border. The symbols chosen are compatible with national & international symbols.

Material Identifier: A designation or identification by any of the following: common name, chemical name, trade name, generic name, code name or code number.



Phrases: Additions or
lements to risks not
eyed by symbols.

autionary Measures: The
ntial precautions to be
n during the handling,
storage of the
ial.

First-aid Measures: The immediate first-aid measures in case of an acute (not chronic) hazard.

Reference to the MSDS: Statements, in both English & French, referring label readers to the more comprehensive material safety data sheet.

Supplier Identifier: The name of the supplier & the city where the principal place of business is located.

INFORMATION TO BE DISCLOSED ON A MATERIAL SAFETY DATA SHEET

	Column I	Column II	Column III
Item	Category	Suggested Headings	Information in respect of controlled products
1.	Hazardous Ingredients	Hazardous Ingredients	(1) Information required by subparagraphs 13(a)(i) to (iv) of the Act
			(2) CAS registry number and product identification number
			(3) LD_{50} (species and route)
			(4) LC_{50} (species and route)
2.	Preparation Information	Preparation Information	(1) Name and phone number of the group, department or party responsible for the preparation of the material safety data sheet
			(2) Date of preparation of the material safety data sheet
3.	Product Information	Product Information	(1) Manufacturer's name, street address, city, province, postal code and emergency telephone number
			(2) Supplier identifier, the supplier's street address, city, province, postal code and emergency telephone number
			(3) Product identifier
			(4) Product use
	Physical Data	Physical Data	(1) Physical state (i.e. gas, liquid or solid)
			(2) Odour and appearance
			(3) Odour threshold
			(4) Specific gravity

INFORMATION TO BE DISCLOSED ON A MATERIAL SAFETY DATA SHEET

	Column I	Column II	Column III
Item	Category	Suggested Headings	Information in respect of controlled products
			(5) Vapour pressure (6) Vapour density (7) Evaporation rate (8) Boiling point (9) Freezing point (10) pH (11) Coefficient of water/oil distribution
5.	Fire or Explosion Hazard	Fire or Explosion Hazard	(1) Conditions of flammability (2) Means of extinction (3) Flash point and method of determination (4) Upper flammable limit (5) Lower flammable limit (6) Auto-ignition temperature (7) Hazardous combustion products (8) Explosion data--sensitivity to mechanical impact (9) Explosion data--sensitivity to static discharge
6.	Reactivity Data	Reactivity Data	(1) Conditions under which the product is chemically unstable

INFORMATION TO BE DISCLOSED ON A MATERIAL SAFETY DATA SHEET

	Column I	Column II	Column III
Item	Category	Suggested Headings	Information in respect of controlled products
			(2) Name of any substance or class of substance with which the product is incompatible (3) Conditions of reactivity (4) Hazardous decomposition products
7.	Toxicological Properties	Toxicological Properties	(1) Route of entry, including skin contact, skin absorption, eye contact, inhalation and ingestion (2) Effects of acute exposure to product (3) Effects of chronic exposure to product (4) Exposure limits (5) Irritancy of product (6) Sensitization to product (7) Carcinogenicity (8) Reproductive toxicity (9) Teratogenicity (10) Mutagenicity (11) Name of toxicologically synergistic products
8.	Preventive Measures	Preventive Measures	(1) Personal protective equipment to be used (2) Specific engineering controls to be used

INFORMATION TO BE DISCLOSED ON A MATERIAL SAFETY DATA SHEET

Item	Column I Category	Column II Suggested Headings	Column III Information in respect of controlled products
			(3) Procedures to be followed in case of leak or spill
			(4) Waste disposal
			(5) Handling procedures and equipment
			(6) Storage requirements
			(7) Special shipping information
9.	First Aid Measures	First Aid Measures	(1) Specific first aid measures

From Schedule I (Section 12)
Controlled Products Regulation

Appendix C

Minutes of the Crop Protection Institute of Canada Responsible Care Container Disposal Committee Technical Taskforce Meeting

February 24, 1988
Regina, Saskatchewan

CROP PROTECTION INSTITUTE OF CANADA
INSTITUT CANADIEN POUR LA PROTECTION DES CULTURES

116 Albert — Suite 710
Ottawa, Ontario K1P 5G3
Tel.: (613) 232-6802

CROP PROTECTION INSTITUTE OF CANADA

RESPONSIBLE CARE CONTAINER DISPOSAL COMMITTEE

TECHNICAL TASKFORCE

MINUTES

DATE: 24th February, 1988

PLACE: The Sheraton Centre, Regina

PRESENT:

B.Taylor - Alberta Environment

K. Price - Alberta Agriculture

S. Ferris - Saskatchewan Environment and Public Safety

V. Chang - Saskatchewan Environment and Public Safety

G. Jesperson - Saskatchewan Agriculture

K. Plews - Manitoba Environment and Workplace Safety and Health

K. Solomon - Canadian Centre for Toxicology

C. Ronden - Applied Polymer Research Canada Ltd.

T. Deslaurier - Applied Polymer Research Canada Ltd.

R. Rose - Crop Protection Institute of Canada, Responsible Care Container Disposal Committee

W. Norn - Crop Protection Institute of Canada, Responsible Care Container Disposal Committee

REGRETS:

B. Todd - Manitoba Agriculture

D. Billett - Saskatchewan Agriculture, represented by G. Jesperson

W. Norn opened the session and outlined the purpose of the meeting, the mandate of the Taskforce and the issues to be addressed. A review of the Technical Taskforce responsibilities was reviewed as outlined per prior correspondence.

Each attendee introduced themselves with a brief outline of their involvement and interest in the Taskforce.

(1) REVIEW OF PRESENT PROVINCIAL PROGRAMS AND CONCERNS

a) Alberta Environment - B. Taylor

- 104 sites in Alberta are full from 1987
- at present a moratorium exists on shredding and landfill
- Minister of Environment has set an April 1, 1988 deadline for plan for 1987 clearance of sites and future program
- landfill is not an option, recycling or high tech incineration are only options
- Alta Environment amenable to recycling
- concern is that program has stagnated
- estimate is that 10% are 3X rinsed as delivered to sites
- need to show end user that 3X activities fit into overall program of pest management

b) Alberta Agriculture - K. Price

- if industry introduces 3X under the P.C.P. act as part of the label, 3X can be enforced
- if program is decided, Agriculture can promote the message
- dealers want nothing to do with collection program (ie: return empties to purchase point)
- power rinser seen as most efficient 3X
- CPIC members must move to all containers/labels/literature promoting 3X
- misleading advertising/representation about toxicology of products is at odds with message of 3X rinsing
- feeling that farmer will be behind program even if they have to pay

c) Saskatchewan Environment and Public Safety - S. Ferris

- review of Saskatchewan program
- metal crushed and baled, goes to smelter
- plastic granulated and stockpiled
- residues collected and go to Ontario for disposal (Tricil - Sarnia)

* SEE ATTACHMENT I

d) Saskatchewan Agriculture - G. Jesperson

- 3X rinse is not being done by farmers
- Saskatchewan is looking for financial support from industry
- 3X rinse program is not being supported by industry on the whole
- farmers support the continuing program of container collection and disposal

e) Manitoba Environment and Workplace Safety & Health - K. Plews

- concern raised about funding and operational management
- concern about the standards of the sites not sufficiently protecting environment
- 3X rinse once 75% of containers now only about 40%
- concern raised about industry switch from metal to plastic becoming dominant and creating a major disposal problem
- residues collected at sites are increasing in pesticide content, about 50% chemical, 50% water
- metal recycling is working in Manitoba
- municipalities have responsibility for crushing containers at the site

(2) TOXICOLOGY - CONCERNS AND POSSIBLE SOLUTIONS

Canadian Centre for Toxicology - K. Solomon

- toxicity of a material(s) is when the dose rate goes above the Accepted Daily Intake
- not triple rinsing a container can leave up to 8% of a product in the container
- 3X rinse can cut personnel exposure in a further cleaning process
- environmental risk due to overload at point source of collection
- synergistic effects of product mixtures at collection sites may make a mixture much more toxic than any single component
- there has been little work on levels of release of leachate from plastic once it has been recycled
- Ontario's 3X plan has been working well
- Ontario landfill sites are starting to refuse containers (3X rinsed or not) as it is difficult to tell which containers have been rinsed or not
- a proposal has been made for a farmer to provide certification at a site that 3X rinse has been done
- a review was given on plastic residue (leachate) methods, based on those used in the food industry

* SEE ATTACHMENT II

(3) PLASTIC RECYCLING - PROGRESS TO DATE, CONCERNS

Applied Polymer Research Canada Ltd. - C. Ronden

- reporting to Alberta Environment next month
- pesticide containers (plastic) can all be recycled into existing markets
- cost of recyclable feedstock must be 35% or less than for new material, for economic processing
- Mr. Ronden outlined, using slides, the present operations of recycling PET beverage containers
- 20 million flower pots produced/annum
- this is one use for pesticide plastic another would be production of HDPE/asphalt geotextiles or plastic membranes
- presently doing tests on plants/seedlings growing in a media of potting soil containing 25% plastic granules made from collected pesticide containers which have been processed through APR pilot plant

- Mr. Ronden stated that he was willing to take over collection/processing operations in Prairie Provinces
- metal and plastic would be reduced in volume at sites by shredding/granulating
- one possibility is the set up of transfer stations in key parts of the province to concentrate materials in certain areas before going to APR Edmonton, or to a smelter/precleaning stations
- cardboard/paper shredded on sites would go to incinerator
- this scheme would extend in future to include automotive oil bottles and household containers
- discussion ongoing with petroleum companies but not yet at toxicology issues.

* SEE ATTACHMENT III

(4) TASKFORCE RECOMMENDATIONS

a) Funding and Management

1) That funding and management issues of container collection operations be resolved by the Policy Taskforce

b) Make 3X Work

1) To make triple rinsing work that triple rinsing is made a part of the label requirements under the P.C.P. Act.

2) That the C.P.I.C. is to ensure that triple rinse is included in all advertising and sales presentations made by member companies.

3) That the Departments of Agriculture continue to promote triple rinse practice on a high level.

4) That a media blitz be undertaken by CPIC, Provincial Environment, Agriculture and Health Departments ie: at points of retail, farm periodicals, extra flyers in container packaging.

c) Clearing Alberta Sites

1) That metal containers remain stored at sites until a metal shredding operation is in place

2) That cartons be compacted and landfilled. (A short term measure only)

3) That plastic be shredded and bagged to reduce site volumes to accomodate 1988 collections (short term)

4) That plastic shredded be transported to collection stations (Lethbridge, Calgary, Red Deer, Edmonton, Peace River as initial selected sites)

d) **Residue Disposal**

1) That residues collected in Alberta are incinerated at Swan Hills

2) That in Saskatchewan and Manitoba for the short term, the present practice be continued (disposal in Ontario)

3) That in Saskatchewan and Manitoba for the long term, residue disposal is to be part of the overall provincial waste management program

4) That volume reduction methods be developed with the program operator

e) **Plastic Recycling Plan**

1) To determine the toxicity of recycled plastic per the present process of Applied Polymer Research, to be undertaken by the Canadian Centre for Toxicology and funded by the CPIC.

2) That if residues of certain products in plastic remain high or unacceptable that a requirement for sale be a change to alternate packaging (PET, metal etc.)

3) That the method of collection utilize mobile shredding and compacting units

4) That provincial pre-clean stations be established until triple rinse is in excess of 95%

5) That cleaned or triple rinsed plastic be sent to a recycler or incinerator (Incineration to be considered only if recycling not feasible)

f) **Site Specifications**

1) That provincial departments of the environment develop uniform standards for collection sites in conjunction/co-ordination with the collection program designer

W. D. Norn

Saskatchewan Environment and Public Safety's

Pesticide Container Disposal Program -

History and Rationale

Saskatchewan's Pesticide Container Disposal Program (PCDP) was initiated in 1983 to:

1. Provide an environmentally acceptable means for the disposal of pesticide containers;

2. Reduce the potential hazards to the environment and public from residues remaining in the containers; and

3. To foster an improved environmental conscience.

Program Operations

The operation of the Pesticide Container Disposal Program is administered by Saskatchewan Environment and Public Safety. The actual crushing, shredding and residue collection operations are performed by contractor(s) hired for these tasks.

Metal containers were singly crushed, then transported to Manitoba for shredding and recycling over the 1983-86 time period. During 1987 metal containers were crushed-bailed then delivered to IPSCO-Regina for recycling.

The shredding of plastic containers began in 1984. Approximately 500,000 pounds of shredded plastic is presently stored near Saskatoon and awaits recycling or disposal.

Pesticide residues are collected during the crushing and shredding operations and are stored at a depot near Regina. The final residue disposal has been contracted to an Ontario company since the beginning of the program.

Pesticide Container Disposal Program -

Operational Statistics

1983-1987

Year	Number of Registered Sites	Metal Containers Crushed	Plastic Containers Shredded	Residue Collected (barrels)	Cost $
1983	192	252,747	—	60	138,600
1984	228	428,994	64,650	96	288,400
1985	259	569,135	87,932	96	378,200
1986	268	663,410	510,223	96	635,000
1987	273	330,701	370,235	74	319,036
Average	—	448,997	258,260	84.4	351,847

Pesticide Container Disposal Program - Present Concerns

Saskatchewan Environment and Public Safety's present concerns with regard to this program are:

1. Ensuring the continued operation of a pesticide container collection-recycling system for the province;

2. Ensuring that the program operates in an environmentally responsible manner;

3. Ensuring the development of functional pathways for the recycling or disposal of the metal, plastic and residue remnants of pesticide packaging; and

4. Ensuring that those who manufacture or use pesticides are responsible for the disposal or recycling of the associated waste containers and residue.

A PROPOSAL TO STUDY PROCEDURES FOR THE DISPOSAL, RECYCLING AND HANDLING OF PESTICIDE CONTAINERS

TO THE

CANADIAN INSTITUTE OF CROP PROTECTION

BY THE
CANADIAN CENTRE FOR TOXICOLOGY

Canadian Centre for Toxicology,
645 Gordon Street, Guelph, Ontario,
Canada, N1G 1Y3. Telephone: (519) 837-3320

Draft of 15:03, Friday, February 26, 1988

1. INTRODUCTION

The disposal of pesticide containers has become of increasing importance with greater awareness of potential exposure of man and the environment to chemicals which may remain in these containers after use. This problem has been exacerbated by the increasing use of plastic containers. Plastic containers, usually made of high density polyethylene, present reduced risks to the user and mixer of pesticides but are potentially less easily recycled or disposed of. Recycling techniques are available for these and similar plastics but the degree of penetration of pesticides into the plastic matrix, the carry-over of residues and the potential for exposure are not well enough understood to support the concept of recycling with confidence.

Earlier work[1] [2] [3] on the rinsing of pesticide containers has shown that significant quantities of pesticide may remain in a container after use of the contents. The amount remaining depends on the nature of the formulation but was reported to range from 0.06 to 3.8% of the contents of the container. This amount can be significantly reduced if a rinsing procedure is followed. The normal recommended method is to triple-rinse the container into the spray tank. This may be carried out by the simple

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1. Braun, H.E., D.C. Morrow, B.D. Ripley and R. Frank. 1983 Efficiency of water rinsing for the decontamination of used pesticide containers. Arch. Environm. Contamin. Toxicol., 12: 257-264.

2. Frank, R., A.J. Stripnieks and B.S. Clegg. 1987. A system for rinsing herbicide residues from drums during highway right-of-way spray operations. Bull. Environ. Contam. Toxicol., 39: 680-687.

3. Miles, J.R.W., C.R. Harris and D.C. Morrow. 1983. Assessment of hazards associated with pesticide container disposal and of rinsing procedures as a maeans of enabling disposal of pesticide containers in sanitary landfills. J. Environmental. Sci. Hlth., 18: 303-308.

procedure of utilizing three successive manual rinses with fresh water or by the use of a power rinsing jet which flushes the contents of the container into the spray tank. This latter process may also puncture the base of the pesticide container thus rendering it unsuitable for other uses as well as leaving a clear indication that the container has been suitably rinsed. While some data has been collected on reductions of pesticide residues in containers rinsed in this manner, this work was carried out on pesticides used in Ontario. The efficiency of similar rinsing procedures with pesticides used in other parts of Canada has not been documented but is unlikely to differ significantly from those of earler studies.

2. RECYCLING OF PESTICIDE CONTAINERS

Plastic pesticide containers may be recycled by a number of processes. Such recycled plastic may not be used to manufacture food containers or similar packaging but is allowed for use in materials through which human or environmental exposure may occur. No information on either the efficiency of the residue removal process or the risk associated with levels which may be present in the plastic after recycling was available. This proposal aims to address this lack of appropriate information through the following:

- Measurement of the levels of pesticide remaining in plastic from pesticide containers after recycle processing.
- Measurement of the levels of pesticide remaining in plastic from pesticide containers after triple rinsing and recycle processing.
- Dislodgability of such remaining residues from recycled plastic products.

- Assessment of human and environmental risks resulting from exposure to such residues as may be dislodgable from recycled plastic products.

2.1. Methods and Materials.

2.1.1. Availability of Pesticide Residues from Recycled Plastic Containers.

Two groups of containers, each consisting of a mixture of plastic pesticide containers will be prepared in the same proportion as the use pattern of pesticides in the prairie provinces. One group will be subjected to a tipple rinse using the following procedure:

> Empty the container into the spray/storage tank, allowing to drain for 60 sec. Add fresh water to a total of 0.1 times the volume of the container, recap and shake for 10 sec. Empty into spray/storage tank and repeat entire procedure twice using fresh water.

The other group of containers will be emptied into the spray/storage tank and allowed to drain for 60 sec but not rinsed unless rinsing specifically indicated on the label (i.e. for flowable suspensions). Both groups of containers will be processed through the regular recycling process (including washing) and then analyzed for residues of those pesticides which were stored in the containers. Degree of removal of pesticide residues will be measured and the probable risk of human or environmental exposure to these assessed.

If significant residues are found in the recycled plastic, this material will then be used to make articles suitable for determination of

dislodgability and leachability. Dislodgability and leachability will be determined using standard techniques[4] and the human and environmental risks of these assessed.

3. ANALYSES

Pesticide analyses will be carried out as follows:

Residues in plastic • A suitable government or contract laboratory e.g. Provincial Environment or Agriculture laboratories or Environmental Test Laboratories, Edmonton; Chemex Labs, Calgary; National Testing Labs, Winnipeg or Wescan Laboratories Ltd, Winnipeg. Final selection to be made by steering committee.

4. ASSESSMENT

Assessments of exposure will be prepared by the Canadian Centre for Toxicology. Assessment of risk will be based on current Canadian Acceptable Daily Intake information, review of the literature, availability of residues and exposure from other sources.

5. PROJECT MANAGEMENT

The project will be managed by the Canadian Centre for Toxicology. The protocol will be refined in co-operation with a steering committee made up of representatives from the respective provincial jurisdictions and the CIPC. The Canadian Centre for Toxicology will co-ordinate all

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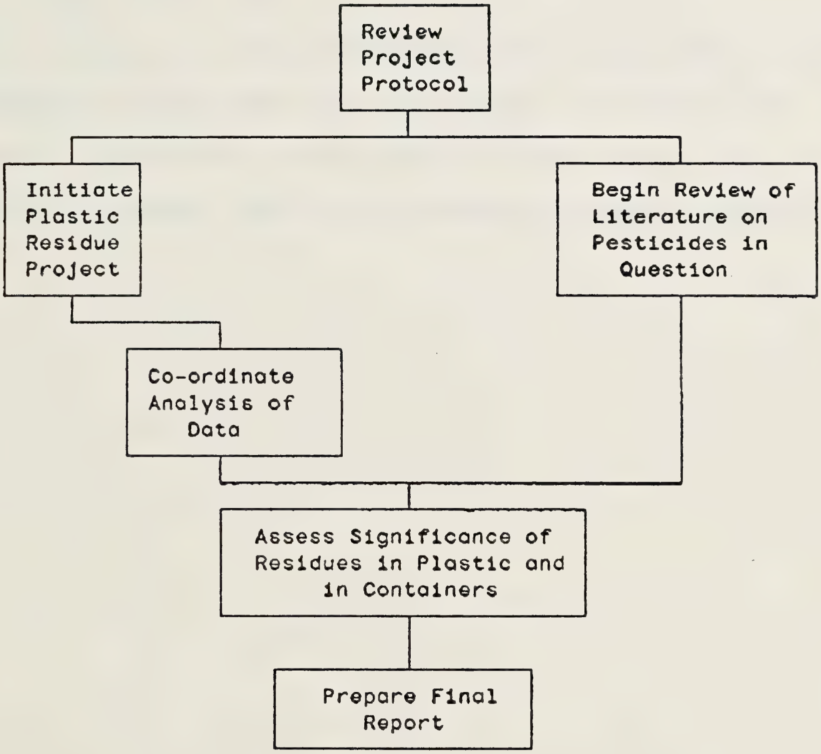
4. Such as those used in the food industry

sampling, will retain analytical services for the analyses on plastic material and will receive all data and reports. The Canadian Centre for Toxicology will assess the relevance of exposure and will provide a final report to the CIPC.

6. PROJECT ORGANIZATION


Review Project Protocol
Initiate Plastic Residue Project
Begin Review of Literature on Pesticides in Question
Co-ordinate Analysis of Data
Assess Significance of Residues in Plastic and in Containers
Prepare Final Report

7. SCHEDULE OF PROJECT

Mar 15	Finalize protocol
Mar 20	Initiate plastic residue project
Apr 15	Review analytical data and assess exposure
Apr 18	Prepare final report
Apr 30	Submit final report

* Note: The most critical information need is the level of pesticide remaining in the plastic after processing. Adherence to the above schedule is dependent on the ability of the analytical laboratory to develop and initiate residue analysis studies as rapidly as possible.

APR APPLIED POLYMER RESEARCH LTD. AND THE RECYCLING OF POST-CONSUMER AGRO-CHEMICAL CONTAINERS:

•DISCUSSION PAPER•

In September 1987, APR Applied Polymer Research Canada Ltd. (APR) was commissioned to investigate the technical and economic feasibility for the recycling of post-consumer Agro-chemical containers. Since that time, extensive literature and early laboratory work suggests that this is technically possible although not economically feasible based solely on the material's intrinsic value. It is anticipated that of the two most likely disposal options - incineration and recycling, the least costly option would be recycling and the following outlines APR's progress to date.

HISTORY

In 1980 the Government of Alberta initiated the Agricultural Container Collection Program. Under the auspices of this program, consumers of the chemicals were to triple rinse the containers after use, render the container unsuitable for further use, and then dispose of them in secured areas of specific landfill and other sites in the province. From these sites, the containers were collected by crews contracted by the department of Environment for this purpose. Typically, the metal containers would be crushed, incorporated into car hulks, and sent to steel mills, the plastics shredded or granulated, and the cardboard boxes landfilled or burnt. Ultimate disposal for the plastics would be limited to burning or landfill.

During the last three years, landfill space was becoming limited with much of the paper continuing to be burnt at the collection sites, and no concern for proper residue disposal. Alternatives were considered - Alberta's first attempt to decontaminate the plastic containers was through Kinetic Resources located in Nisku. Kinetic's techniques were not found to be environmentally sound and consequently abandoned. Meanwhile concerns were being raised about present disposal practises, landfill sites were becoming harder and harder to find, an unfortunate accident happened, and the steel mills began to refuse the metal containers - these events brought everything to a head, and work in the province was halted. Safe alternatives had to be developed.

In 1984 the Government of Alberta established the Alberta Special Waste Management Corporation to develop, oversee, and manage the Alberta Special Waste Treatment Centre near Swan Hills. This facility was brought onstream in mid 1987 and the technical success of this facility is unquestioned - controlled thermal destruction under the proper conditions has been proven to completely destroy pesticide residues . The incineration process, however ultimate its disposal, consumes large amounts of energy which in many instances renders the process uneconomical. Therefore there remains an incentive to develop other disposal or decontamination alternatives.

In 1985, APR began recycling post-consumer PET beverage bottles using a proprietary process developed in-house, and had recently introduced its manufacturing division Applied Polymer Products (APP). APP had been blowmolding industrial flower pots from reprocessed high density polyethylene scrap, and has continually been faced with increased resin costs and scarcity of supply. As it is uneconomical to use virgin resin in this application, new resin sources required (and continue to be) established. APR was aware of the waste disposal problem presented by post-consumer Agro-chemical containers, and saw it as an opportunity to obtain much needed raw materials for APP. APR approached the Department of Environment in March 1987 with a proposal to collect and dispose of post-consumer Agro-chemical containers for the province, and in September 1987 was awarded a contract to investigate the technical and economical feasibilities for doing this.

COLLECTION

There are five criteria which must be met for recycling to be successful as shown in Figure 1. These are:

- a continuous source of adequate material.
- a suitable collection infrastructure.
- proven recycling technology.
- acceptable end-use applications.
- favourable economics.

With the source established, container collection became the first criterion to be considered. Talks with contractors used in previous year's container collection programs in Alberta were initiated, and strengths and weaknesses of the past were established. The following became evident:

Strengths	- economical - multi-sectoring of collection operations
Weaknesses	- poor disposal methods - competitive bidding nature of contract granting (encouraged the lowest bidder, discouraging continuity and long-term responsibility) - poor supervision - present move towards the hauling of whole containers long distances, eliminating shredding in the field

From these discussions, APR has formulated a collection infrastructure based on what it perceives as the best compromise. What is proposed is to haul whole containers to *Primary Decontamination And Transfer Stations.* It is anticipated that 3 or 4 such sites would be located throughout the province. At these locations, the containers would be shred to increase bulk density, their residues drained, and the materials suitably packed for transport. This configuration is shown in Figures 2&3. These stations

would be fenced to increase security and because this scenario would see most of the work being carried out at a few locations, they could be better supervised, and the equipment made safer (not be meant for portable use). These stations could also serve as base camps for the collection crews, reducing living expenses.

From these sites, the materials could be transported in bulk to a central *Waste Processing And Treatment Facility* where final decontamination of the plastics and residues would take place and the metals would be cleaned sufficient for acceptance at local steel mills.

RECYCLING TECHNOLOGIES

By modifying APR's existing recycling technology, and by the incorporation of suitable wastewater treatment, the wastes would be treated to render the materials safe to health and environment. Two treatment technologies investigated to date which early studies indicate are capable of treating the wash waters and residues from such an operation, and render them safe. These technologies are the topic of patent applications currently being filed. Details on these processes as well as proposed flow charts will be presented in the report for Alberta Environment to be completed by March 31, 1988.

The PE resin yielded from the containers would be recycled into suitable plastics products, their suitability determined by adequate testing of the polymer for the intended use. As very little has been done in the past to develop testing methods for materials of this nature, much work is yet required to develop economical, acceptable test methodologies.

TESTING

Testing to date includes laboratory testing on the treatability of residues and wash waters, washing and blow molding trials, bio-assay experiments, and initial analytical testing.

Washing and blowmolding trials carried out on recycled Agro-chemical containers has confirmed that reuse of the HDPE from this source is feasible for the intended use of APP.

Bio-assay experiments have begun to determine the effects of pesticide contaminated plastics mixed into the growth media of plants. Trials are presently in the very early stages for these experiments, and no data is available at this time. Details of these experiments will be included in the final report.

Early attempts to quantify contaminant levels in used, unused, and washed samples of post-consumer Agro-chemical containers has also been initiated, however the laboratory results are not available at this time.

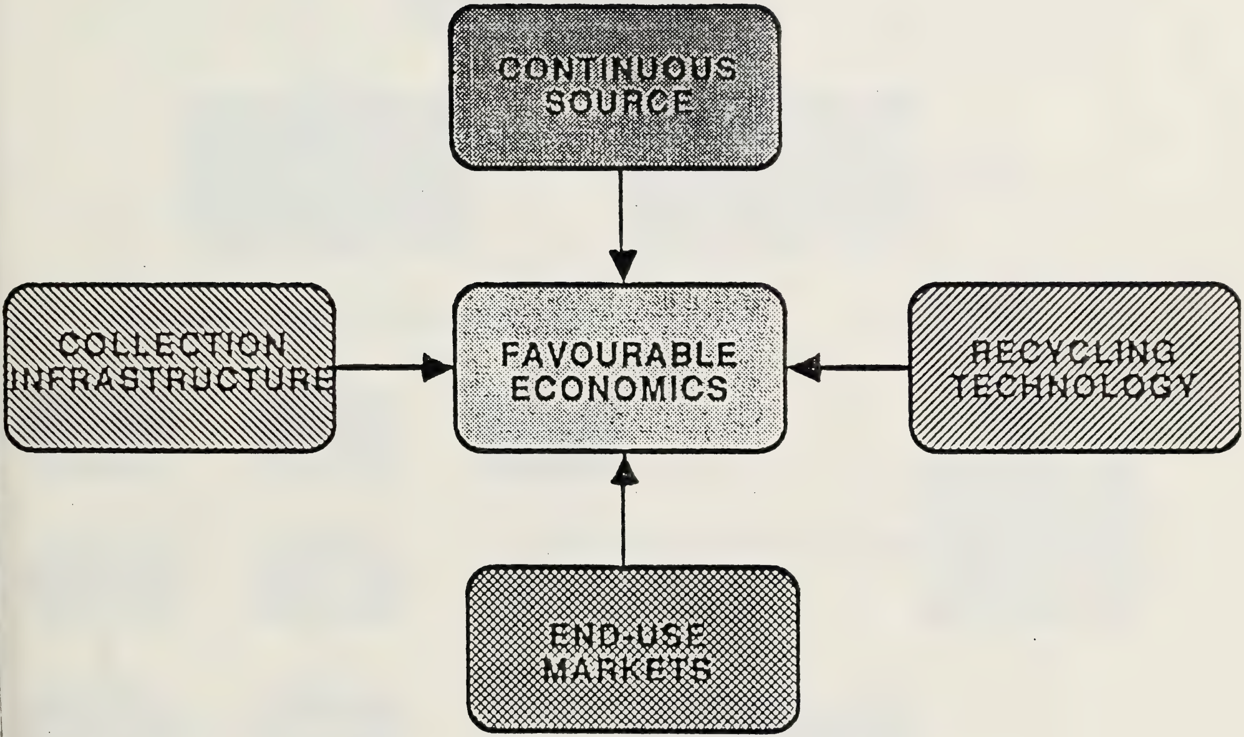


FIGURE 1:The Five Criteria For Succesful Waste Plastic Recycling

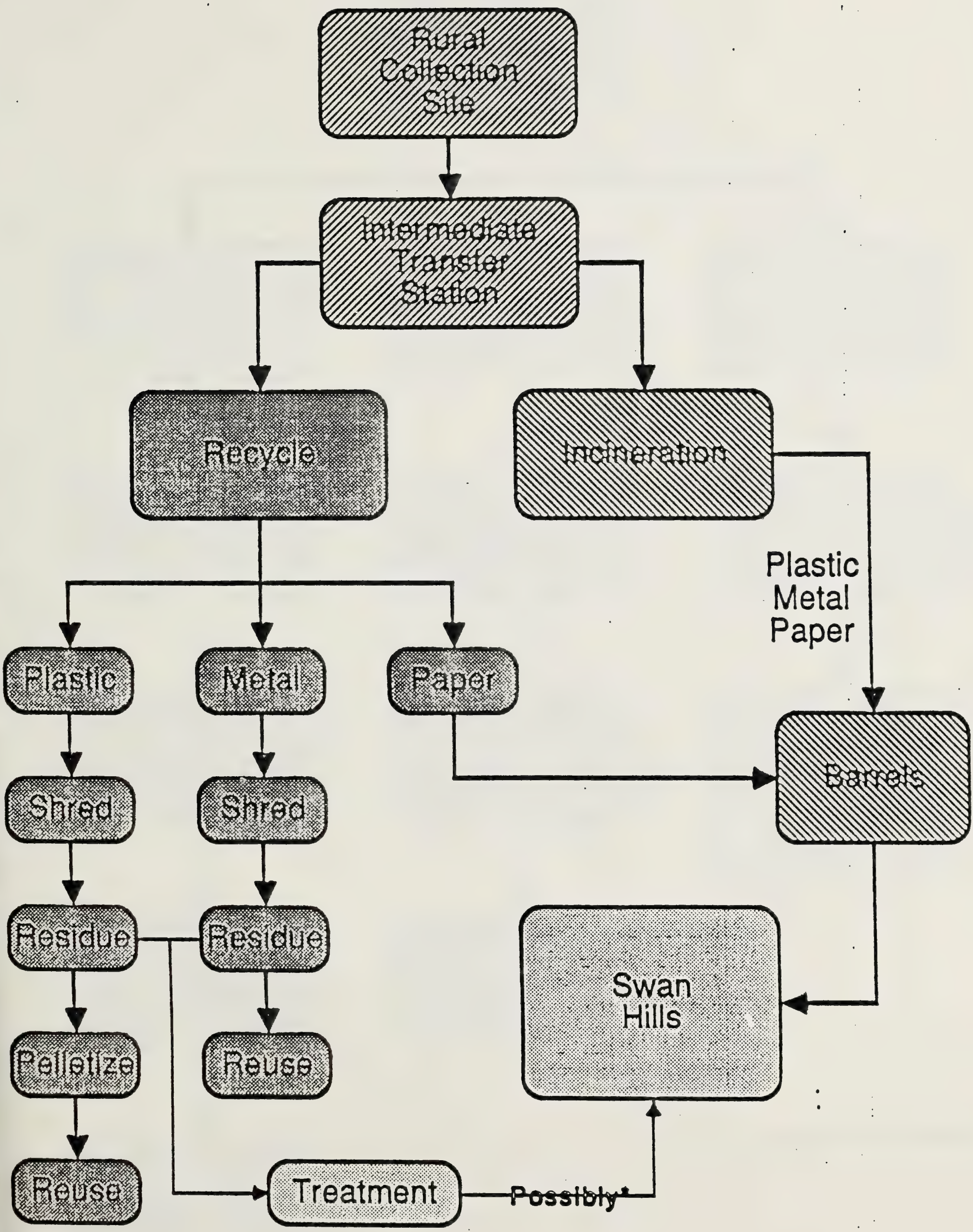
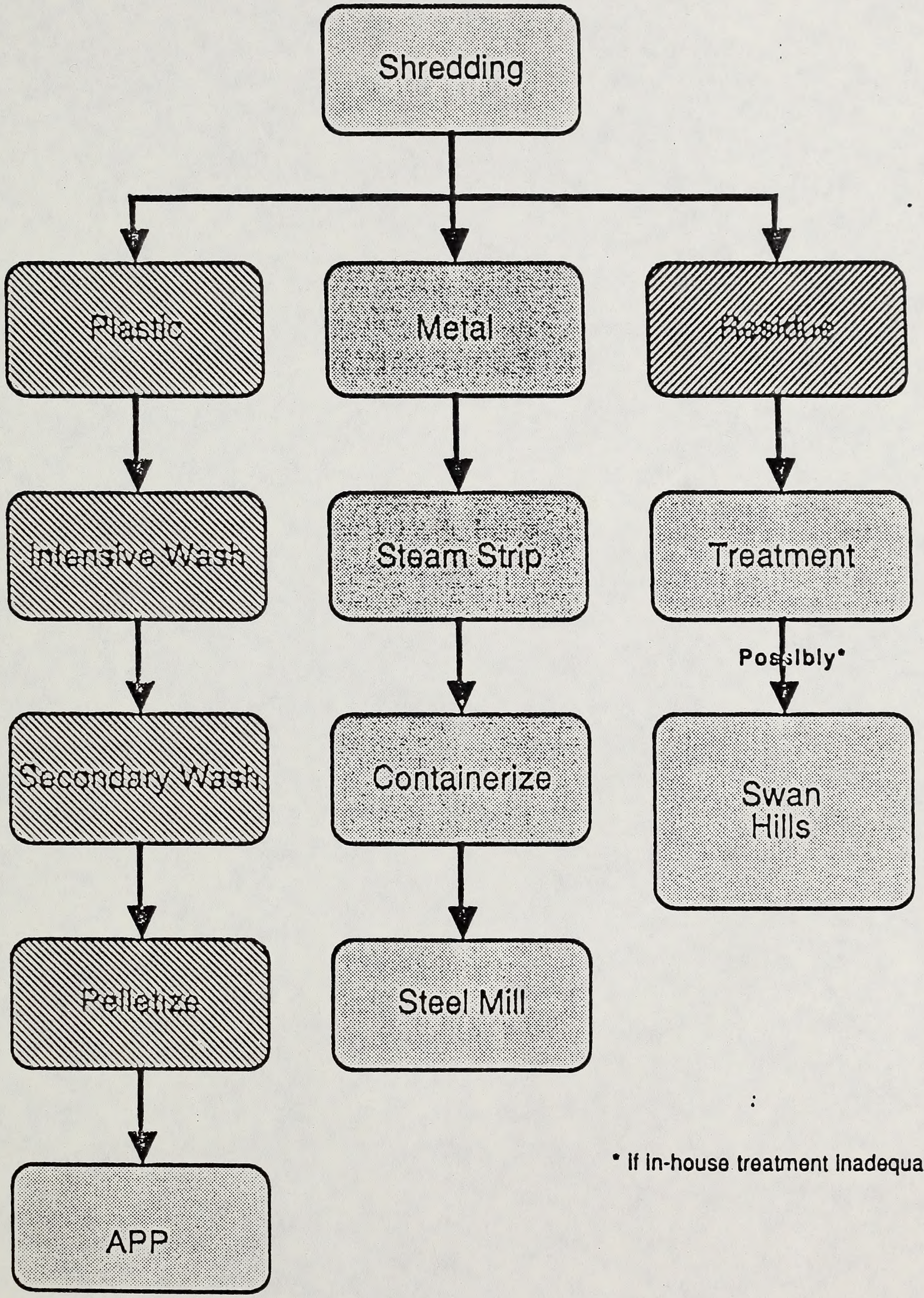


FIGURE 2: The Logistics For Handling And Disposal Of Waste Agri-Chemicals: Two Alternate Schemes

* If in-house treatment inadequate



* If in-house treatment inadequate

FIGURE 3: Container Recycling Process Streams

N.L.C. - B.N.C.
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